Guide Book

Right start
Foundation
Damp proof course
Cement concrete
Stone & Brick Masonry

A compilation by

P N Sarin

Other compilations by
P N Sarin

1. Survey, Engineering Materials, Seismic, Termite & Pest Control
2. Right start, foundation, DPC, stone & Brickwork
3. Plaster, Finishes. Roof, Floor, Stairs
4. Steel, Reinforcement, Shuttering, Timber, Woodwork, Glazing
5. Electric Supply, Light, Air-Conditioning
6. Water supply, Sewage
7. Maintenance of Building
8. Domestic Pest Control
9. Numerals & Mensuration
10. Units of Measurements & Conversion Factor
11. Indian, British & US Units Of Measurements
12. Terms related to Business, Legal, Sports & Games
13. Abbreviation, Acronyms, Quotes
14. Sign, Symbols & Acronyms
15. Kitchen, Cooking and Upkeep
16. Cleaning and Laundry Work
17. Food Adulteration
18. Household tips (काम की बातें)
19. Gems, Astrology & Astronomy
20. Health Hygiene, Homoeopathy एवं घरेलू उपचार
21. Safety & Precautions
22. Time (समय)
23. Carom Rules (Official)
24. Dictionary of Computer Terms
25. Computer Basic Terms and Upkeep
26. Dictionary of Units of Measurements
27. Indian currency, RBI rules, how to detect Fake Currency

Antiquarian collection

28. बृहज्जातक - पण्डित महीधर शर्मा (1884)
29. लघुपाराशरी – पण्डित मदन मोहन पाठक
30. लग्नजातक एवम राशिमाला
31. औषधप्रकाश – वैध माधव दास जी (1909 Print)
32. सर्वतोभद्रचक्रम – पण्डितए मीठालाल जी व्यास (१९४० Print)
33. समुद्रशास्त्र (हस्तरेखा शास्त्र)
34. Tezi Mandi (तेज़ी मंदी), Indian & Western Astrology (extracts)

Well building hath three conditions: Commoditie, Firmenes, and Delight".
English poet Sir Henry Wotton (1568–1639)

Contents

Building Construction 7
Make the right start 7
Options for plan for a house 7
Details 7
Orientation of building 8
Layout of angles at ground 8
Set an right angle with a measuring tape .. 8
Set a line at right angle from a given point 8
Set an angle of 90º 9
Set an angle of 60º 9
Set an angle of 45º 10
Set an angle of 30º 10
Important don'ts during construction 10
Storing/stacking materials 10
Excavation 11
Foundation concrete 11
Concrete 11
Stone masonry 11
Brickwork 11
Damp proof course 12
Form work 12
Reinforcement 12
Joinery 12
Plastering & pointing 12
Flooring 12
Terrazzo flooring 12
Cement paint 12
Painting 12
Glazing 13
Ventilation 13
Terminology 13
Technical terms 13
Parts of a building 20
Composition of a house 21
Where man lives or works 23
Composition of country 25
Cement 26
History of ACC cement 26
Varieties of cements 26
Blended cement 27
Ordinary Portland cement 27
Portland pozzolana cement 27
Rapid hardening Portland cement 27
Low heat Portland cement 27
Quick setting cement 27
Portland blast-furnace cement 28
High-alumina cement 28
Acid-resisting cement 28
Waterproof mastic cement 28
Setting of cement 28
Which cement to use 28
Indian standard Specifications 29
Facts about Portland cement 29
Difference between White Cement and Wall Putty? 30
Field tests for cement 30
Stacking & preservation of cement 31
Strength of stored cement 31
Effect on strength on concrete 31
Shrinkage of cement & mortars 32
Measurement of cement 32
Size for measuring box for 50 kilograms cement bag 32
Quantities of materials 32
Mortar mixes 32
Lime mortar mixes 33
Lime gauged mortar 33
Concrete mixes 33
Cement constants 34
50 Kilogram of cement will make concrete 36
Tools & plants for concrete work 37
Vibrator 37
For concretes cast in place 37
Internal vibrator 37
External vibrator 37
Surface vibrators 37
Plate vibrator 37
For pre-cast work 37
Platform vibrators 37
Table vibrators 37
For road slabs 37
For very large capacities 37
Concrete mixer 37

Tilting mixer 38
Capacity of batch (concrete) mixer 38
Aggregate 38
Fine aggregates 38
Surkhi 38
Sand 38
Graded sand 38
Fine sand 39
Coarse sand 39
Good sand 39
Cleaning of sand 39
Testing of silt in sand 39
Bulking of sand 39
Phenomena of bulking 40
Test for bulking of sand 40
Process 40
Applying the test 41
Quantity of surface water carried by aggregates 41
Approximate water absorption of aggregate 41
Functions of sand & surkhi 41
Coarse aggregate (or stone) 42
Graded aggregate 42
Gap graded aggregate 42
Pebble 42
Flint 42
Fly ash 42
Lime stone 42
Lime 43
Properties & classification of lime 43
Concrete plain/reinforced 43
Composition 44
Construction Techniques 45
Concrete Masonry 46
Columns 47
Slenderness ratio 47
Long column 47
Short column 47
Reinforced Concrete or Ferro-concrete 47
Mass concrete 48
Plain concrete 48
Reinforced concrete 48
Anti-crack reinforcement 48
Cracking in reinforced concrete 48
Pre-cast concrete 48
Vibrated concrete 48
Dense concrete 49
Vacuum concrete 49
Vacuum mat 49
Mixes of concrete 49
Nominal mix of concrete 49
Volumetric mix 49
Crushing strength of cement concrete 50
Initial setting time 50
Workability cement concrete 50
Water in concrete 51
Importance of quantity of water for mixing 51
Water cement ratio 51
Abram's law 51
Curing of concrete 51
Defects or failure of concrete 52
Creep 52
Honeycombing 53
Laitance 53
Shrinkage 53
Dusting 53
Effects of various materials on concrete 53
Effect of frost 53
Substances & liquids 53
Moisture movement 59
Foundation 60
Excavation & earthwork 60
Soils 60
Classification of soils 60
Size of soil particles 60
Safe bearing pressure/capacity of soils 61
Types of foundations 61
Groundwater level 62
Pile foundation 63
Volume of one UR portion of a pile 63
Volume of 1 under reamed portion of pile of different dia 63
Sections of grid beam & pile stem 64
Setting out foundations for excavation 66
Details of foundations 66
Foundation 1-brick thick wall 66
Foundation 1½-brick thick wall 66
Foundation 2-brick wall & pillar 67

Excavation for foundations 67
Workmanship 67
Av output of a excavator labourer 67
Excavation in trenches 68
Returning filling in trenches 68
Pre-construction anti-termite measures in buildings 69
ATT for load bearing walled structure along external perimeter 69
Soil treatment to partially erected buildings 72
Foundation concrete 72
Damp proof course 73
Stone masonry 73
Ashlar stone 73
Ashlars, soft stones 73
Ashlar, hard stone 73
Rubble 73
Random 73
Bond stones 74
Lap of stones 74
Dressing – stone masonry 74
Ashlars 74
Ashlar chamfered 74
Ashlar fine 74
Ashlar rock faced 74
Ashlar rough-tooled or bastard 74
Ashlars rustic 74
Block-in-course 74
Rubble masonry 74
Random rubble (second sort) 74
Random rubble (first sort) 75
Rubble 75
Rubble coursed 75
Rubble sneaked 75
Cement constant 75
Brick masonry 75
Terminology 75
Bricks 77
Size of bricks 78
Standard brick dimensions 78
Measurement of bricks 78
Modular brick 78
Characteristics of good Brick 78
Brick masonry 79
Types of bonds in brickwork 80
American bond 80
Basket bond 80
Chinese bond 80
Dutch bond 80
English bond 81
Flemish bond 81
Flemish bond, double 82
Garden bond (Flemish garden bond) 82
Header bond 82
Herringbone bond 83
Herringbone 90 degree 83
Rat-trap bond 83
Soldier course 84
Stretcher bond 84
Three & one bond 84
Use of closure 85
Joints in brickwork 85
Strength of brickwork 86
Workmanship Brickwork 86
Testing of bricks at work site 86
Workmanship 87
Construction of walls 1-brick thick & over 88
Construction of walls ½-brick thick 89
Requirement of cement 89
Estimating –brickwork 90
Lightening calculations of materials 90
Calculations of number of bricks 90
Thumb rules 90
Quantities of mortars 91
Qty for Metric size bricks (modular bricks) 91
Analysis 91
One-brick thick wall 91
Half-brick thick wall 91
Details of 1-brick thick walls 92
Details of 1½ -Brick thick walls 93
Details of 2 & 3 -Brick thick walls 94
Details of 2 -brick walls & attached piers 95
Parapet Walls 95
Fire resisting materials 95
Columns & piers 95
Water penetration 96
Efflorescence 96

Treatment of efflorescence..... 96

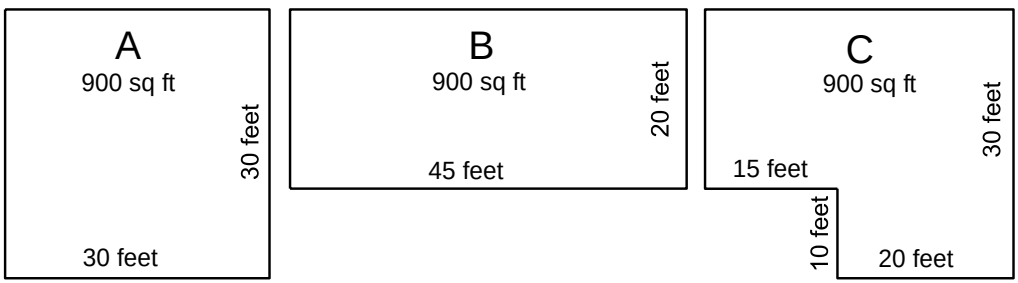
Building Construction

Make the right start

1. During construction of a new house, take care of these design and building details to ensure basic safety:
2. The main door should open out rather than in
3. A door is only as good as the lock on it. A lock should go into the wall, ground, or roof.
4. The doorframe should be of heavy-duty construction.
5. The location of the kitchen should be such as to afford a full view of the main entrance.
6. Grills should be grouted and not screwed on to the frames
7. Glass door or large window should be avoided.
8. Windows and balconies should not be accessible from a tree or drain pipes.
9. All doors leading out of the apartment/house should have Mortise lock ([a hole in the door to receive the end of another piece so that the two are held together) with a throw of at least 25 mm, constructed of case-hardened steel. Spring latches and knob locks are easy to open.
10. Both the front and back doors should have Magic eyes and safety chains

Options for plan for a house

The three houses shown have the same floor area. The house 'A' is most economical; 'C' will cost more than 'B' due to the added cost of exterior corners even though the area of walls is same as the house 'B' and 'C'. The house 'B' would be more costly to build than the house 'A' due to the additional lineal feet of wall (refer the chart given below).



Details

House	Floor area	Lineal feet of wall	Numbers of corners
	Sq feet	Feet	
A	900	120	4
B	900	130	4
C	900	130	6

Orientation of building

Orientation is specifically, construction with reference to the east; generally, the term is applied to the determining of the direction in which a building is to face. In case of square buildings, orientation refers to the direction of the normal to the long axis. For example, if the length of the building is East-West, its orientation is North-South.

The following orientation may be adopted according to the prevailing monsoon winds.

Northern India	*Orient along East and West, facing North*
Central India	*Orient along East-South East & West-North West, facing North-North East*
West coast regions	*Orient along South East & North West, facing South West*
East coast regions	*Orient along South East & North West, facing North West*
Bengal	*Orient along East & West, facing South*

The layout of an athletic field is carried in such a manner as to keep the sun away from the eyes of contestants, etc

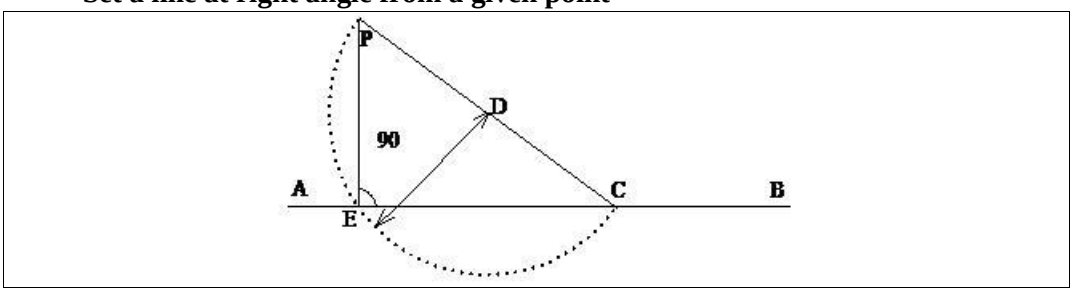
Layout of angles at ground

Set an right angle with a measuring tape

For layout of foundation on ground select a suitable corner point and fix one peg duly nailed at its centre. Measure out a triangle, as stated below, first by setting the outer line of front or side wall [to be treated as line AB] with the help of tape of any convenient multiple of 3, 4, and 5: as 30, 40, and 50 or 6, 8, and 10, etc. keeping longest side opposite the centre of the peg. (The right angle is opposite the longest side).

When all the right angles of building or rooms are set as per drawing, check both the diagonals for accuracy of all right angles at each corner of the room.

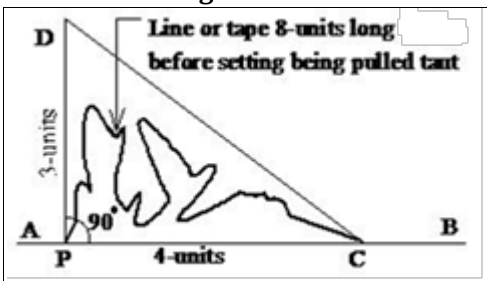
Set a line at right angle from a given point



From a given point outside the line

1. AB is given line and P is the given point from which the line at right angles to AB is required.
2. Take a length of tape or rope about twice as long as the distance P from the line AB and attach a peg to each end of the tape or rope.
3. Drive one peg at P and the other at C where the tape meets the line AB. Drive a third peg at D, the centre of PC and fix the tape to it.
4. With D as centre and length of tape being equal to DC, swing it to cut the line AB again at E. it will also cut at P, if the measurements are correct. Drive a fourth peg at E.
5. The line PE is at right angles to AB.

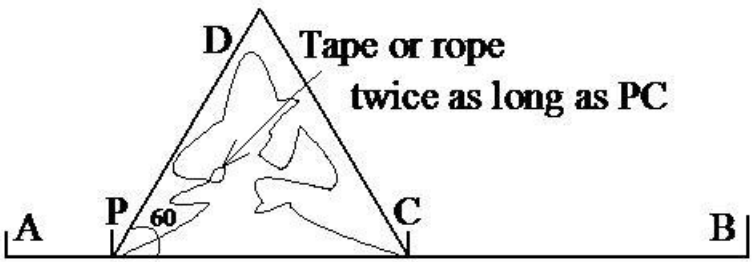
Set an angle of 90º



From a given point on a line

1. AB is given line and 'P' is the point from which a line at right angles is to be set out.
2. Drive a peg P and another peg C on line AB so that PC is equal to 4 units.
3. Take a length of tape string; attach it at P and C so that the length of tape between the pegs is 8-units.
4. Along the tape measure a length of three units from P. Grip the tape at this point and draw taut, drive in a third peg at this point D. The line PD is right angle to AB

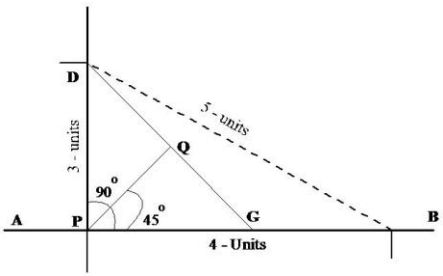
Set an angle of 60º



At point 'P' on line AB

1. Drive one peg at P and another peg at any convenient point C on line AB.
2. To the pegs, P and C attach ends of a tape so that length between pegs is twice the distance PC.
3. Grip the centre point of tape, draw it taut on both ends, and drive a third peg at this point D. the angle DPC is 60º.
4. Since, the three sides of a triangle PCD all are equal in length the three angles are also equal to one another, i.e. they are 60º.

Set an angle of 45º

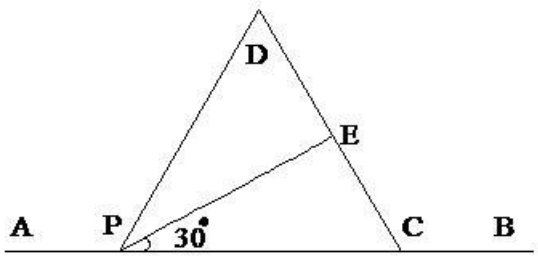


At point 'P' on line AB

Set an angle of 90°, mark PG = PD.

Bisect the DG and draw line PQ. Angle Q P G is 45º.

Set an angle of 30º



At point 'P' on line AB

1. Proceed as for drawing an angle of 60° leaving the pegs at C and D.
2. Mark centre point on line CD with a fourth peg E.
3. The line PE bisects the angle D P C i.e. to divide into two equal parts. The angle E P C is, therefore, 30º.

Important don'ts during construction

Storing/stacking materials

1. Do not store cement in damp condition. Ensure proper dunnage for storing cement
2. Do not stack cement more than seven bags high. Ensure ordinary Portland cement and Portland Puzzolana or slag cement is stacked separately.

3. Do not disturb or restack the cement until it is taken out for use.
4. Do not stack aggregate on expansive soil like black cotton soil.
5. Do not keep mixed stacks of different sizes of aggregate to gather.
6. Do not use the last bit of sand, which is bound to be unclean.
7. Do not allow aggregates to be compacted when filled in measuring boxes.

Excavation

1. Do not lay foundation concrete until hard soil / moorum / rocks is met with.
2. Do not go with mason's advice in case of loose or black cotton soil or for multi storied building. Always consult engineer/expert.
3. Do not allow expansive soil or silt filling in trenches.
4. Do not lose sight of measure for anti-termite soil treatment if termite mounds exist nearby or in the site of work.
5. Do not dug further or add earth in the trench after anti termite treatment.

Foundation concrete

1. Do not allow the labour to throw the concrete in the foundation trench from a height of more than 1-metre. Employ one extra labour to receive the concrete by standing inside the trench and pour it where required by the concreter.
2. Do not let the excavated earth fall in the foundation trench during and after the concrete is laid.

Concrete

1. Do not allow further ramming/ vibration of concrete once the concrete is set.
2. Do not allow concrete to be thrown from a height.
3. Do not do excessive vibration. Otherwise segregation will start.

Stone masonry

1. Do not use laminated/ porous stones.
2. Do not allow bond stone to protrude.
3. Do not allow thicker joints.
4. Do not allow discriminating put log holes.
5. Do not allow timber/ steel to be embedded unless tarred.
6. Do not allow building more than 1.5-meter high masonry works on any one-day and no portion is higher than the adjacent by more than 1 meter.
7. Do not allow weak scaffolding or ladders there by endangering safety.
8. Do not leave stonework in 'toothed' position; it should be done in 'stepping' position.
9. Do not allow chase and holes after completion of stonework.

Brickwork

1. Do not allow use of under soaked bricks.
2. Do not allow bricks of different sizes in the same work.
3. Do not allow use of brickbats except where closures are required.

4. Do not allow thick joints.
5. Do not allow mortar to be filled after bricks are laid in position.
6. Do not allow hammering.
7. Do not leave brickwork in toothed position; it should be in 'stepped' position.
8. Do not allow chase and hole after completion of brickwork.

Damp proof course

1. Do not allow any unevenness in the surface
2. Do not commence superstructure until damp proof course is cured for 48 Hours.

Form work

1. Do not allow rickety formwork or yielding supports.
2. Do not remove formwork until concrete has hardened.
3. Do not allow any rubbish particularly chipping, shavings, and sawdust in the interior of the forms.

Reinforcement

1. Do not use rusty reinforcement.
2. Do not allow laps at situation of maximum bending moment. Ensure laps are staggered.
3. Do not use too many small lengths.
4. Do not allow worker trample on the reinforcement.

Joinery

1. Do not use nails. Use hardwood or bamboo pins in securing joints.
2. Do not allow screws to be hammered.

Plastering & pointing

1. Do not allow excessive trowelling.
2. Do not allow a wavy finish.

Flooring

1. Do not allow trowelling /floating after concrete is set.
2. Do not allow worker to walk over finished concrete laid previously.
3. Do not reduce curing period.

Terrazzo flooring

1. Do not heap up the mix of cement, pigment, and aggregate so that bigger aggregate falls to the bottom.

Cement paint

1. Do not uses cement paint on non-porous surfaces, gypsum plaster or lime wash.
2. Do not use on smoothly finished surface.

Painting

1. Do not use paints of different brand simultaneously.

2. Do not use painting during rainy/stormy weather or when the atmosphere is dusty. Morning hours are generally more suitable.
3. Do not use painting on wet surface.
4. Do not use painting on surfaces, which have not been prepared to receive paint.
5. Do not allow painter to use of thinner indiscriminately.
6. Paint is always well stirred before and during use.

Glazing

1. Do not procure glass panes, which are wavy and have stains/streaks.
2. Panes should be sprigged and back puttied. Use brads and not tacks.
3. Use only correct putty.

Ventilation

A healthy man requires 300 cubic feet air per hour for proper ventilation. A sick man requires 1200 cubic feet air per hour for proper ventilation. In prisons and warehouses 350, assemblies 550, hospitals and barracks 2200, infectious hospitals 4400, schools, infants 618, adult 1235 cubic feet air per person per hour.

Outlets of rooms: - 1 square inch to 50 to 60 cubic feet of room.

Each person requires 3 to 4 cubic feet of air per minute. Ordinary windows allow 5 to 8 cubic feet of air per minute to pass.

Terminology

Technical terms

Altitude उँचाई	The elevation of a place above sea level The angular height of a star above the horizon The angular distance of any point of celestial sphere, measured from the horizon, on the great circle passing through the body and the zenith
Anneal तापानुशीतित	Bring to a desired consistency, texture, or hardness by a process of gradually heating and cooling
Annealed wire	Binding wire: Soft steel wire (usually called iron wire), used for binding reinforcement
Arris (उत्कोण)	The meeting of two surfaces producing an external angle
Artisan (कारीगर, शिल्पी)	One who works with his hands and manufactures articles in metals, wood, etc.
Barrel (नली)	That portion of a pipe in which the diameter and wall thickness remains uniform throughout
Bastard	A term frequently applied to anything, which does not confirm accepted norms as bastard tuck pointing
Batter	The slope away from you of a wall or timber piece, etc.

Berm (पटरी)	A shelf that breaks the continuity of a slope or a narrow edge of land (usually unpaved) along the side of a road
Bevel (गुनीया)	Any surface not in right angle to the rest of the piece. Any inclination of two surfaces other than 90 degree (Either greater or less)
Bloom (फूलाव)	The appearance of efflorescence on the surface of the wall
Buttress	A vertical-supporting member built on the exterior of a wall and properly bonded to it to enable it to resist the outward thrust.
Casement	A window sash that is hinged (usually on one side)
Causeway	A raised road or path across low or wet ground.
Chamfer (तिरछा किनारा)	A bevelled edge or cut off corner. To cut off, in a small degree, the angle or arris formed by two faces, usually at an angle of 45 degree.
Charcoal	Charcoal is Wood, which has been charred and carbonised.
Chase	A lengthwise groove for the reception of a part to make a joint
Chocks	Block behind chowkhats to prevent further motion of door shutter toward jamb.
Clay	A common earth, compact and brittle when dry, but plastic when wet. Used in the manufacture of bricks.
Coal	A solid brown or black, inflammable substance dug from the earth
Coal tar	The black pitch distilled from bituminous coal condensed in the manufacture of coal gas; coal tar can be further distilled to give various aromatic compounds
Cobble (बटिया)	A rock fragment, usually rounded or half-rounded, with an average dimension between 80 and 300 mm; used to make roads
Coke	A fuel made by baking bituminous coal in closed oven to drive off gases and other elements. Coke is 88% carbon.
Cold rolled	May be either open-hearth or Bessemer process. The steel is marketed with a bright, smooth surface and is made quite accurate to size.
Column	An isolated vertical load-bearing member, the width of which does not exceed four times the thickness
Contraction	Decrease in volume due to cooling.
Cowl (टोप)	Hood shaped covering for a chimney, vent pipe.
Crazing	Very fine cracks in the glaze on a piece of a ware due to unusual shrinkage between glaze and the body often caused by improper firing.
Creosote	A dark oily liquid obtained by distillation of coal tar; used as a preservative for wood
Culvert	A covered channel for the passage of water, as under a road
Cumulative	Steady increases in quantity or value by repetition or addition

DDT	DDT is a colourless chemical that kills insects and is harmful to animals and humans. It has been banned in many countries since 1974 because of its toxicity, its persistence in the environment, and its ability to accumulate in living tissue. Formula: C14H9Cl5. Full form dichlorodiphenyl-trichloroethane
Dilate	To swell, inflate, to spread or increase in all direction.
Ductile	1. capable of being hammered out thin, as certain metals; malleable. 2. capable of being drawn out into wire or threads, as gold 3. able to undergo change of form without breaking 4. capable of being moulded or shaped; plastic
Drip moulding	a projection from a cornice or sill or chhajja designed to protect the area below from rainwater (as over a window or doorway)
Eaves (ओरी)	The projecting edge of a roof is called 'eaves'. The part of roof jutting over wall
Feather edge	A keen edge, tapering off to nothing
Fevicol 'DDL': it is used for mixing in lime wash solution	
Fevicol or Fevibond 'SH': it is used for carpenter work	
Fillet (पट्टिका)	Fillet is a concave curve connecting two surfaces, which meet at an angle. By avoiding sharp angles, it adds to the strength and beauty of a design.
Finial (स्तुपिका)	A decorative fitting used at junction of ridge and hip, and at the top of conical, pyramidal or dome roof
Flagstone	It is a thin-bedded variety of sandstone having a grey or bluish colour.
Flint (चकमक)	A very hard grey stone that can produce a spark of fire when struck against steel
Floor (फर्श, तल)	1. The ground on which people and animals move about 2. Another name for a story as a unit of height for buildings. In Britain, the floor above the ground floor is usually called the first floor, so a three-floor building has four stories. In the U. S., the numbering of floors is most often the same as the numbering of stories.
Forge (गढ़ना)	To form a piece of metal by hammering while it is hot
Gate valve	A valve whose action depends on the motion of a wedge- shaped gate between the inlet and outlet openings.
Gauge (माप-नाप, पैमाना)	An instrument or device for measuring and indicating a quantity such as the thickness of wire or the amount of rain etc. The thickness of wire or metal sheet
Glass	A brittle transparent solid with irregular atomic structure and is sometimes transparent like volcanic slag, or pottery glazes, or household glass.

Glass wool & lead wool	Glass wool and lead wool are synthetic mineral fibbers spun and massed into bundles resembling wool.
Glazing	Fitting door/window glass panes
Globe valve	In which a disc operated by a screw and hand wheel seat on a circular opening on the underside of the seat.
Gloss	A glazed surface, which has a shining, lustrous finish
Gravel	Rock fragments and pebbles; untreated or only slightly unwashed, rounded, natural building aggregate, larger than 4-mm
Gutter (नाली, पनाला)	A channel along the eaves of a house to carry off rain or a bricked or paved surface in the street adjoining the curb
Hacking	The roughening of solid backgrounds, by hand or mechanical methods, to provide a suitable key
Hardcore	Hard lumps of stone, brick, and furnace slag, old concrete, etc., suitable for filling soft ground in a foundation. Under a floor or under a road, etc.
Haunching	Concrete bedding with additional concrete at the side of the pipe
Herring-bone	Masonry work [generally in floors] in which the bricks are laid slanting in opposite directions.
Hydroscopic	A substance that attracts water from the air
In-situ	In the correct position; undisturbed
Invert	Invert is the lowest point of the interior of a sewer or drain at any cross section. In a manhole chamber, the channel in the floor of the chamber which carries the flow of sewage through manhole
Ironmongery	The merchandise that is sold in an ironmonger's shop. Tools, household implements, etc.
Jamb	The part of the wall at the side of an opening or upright consisting of a vertical side member of a door or window frame
Joist (कड़ी)	Beam supporting a floor.
Lac (लाख)	Lac is a secretion of the Lac insect.
Latitude (अक्षांश)	Distance of a place north or south from the equator measured on the earth surface in degrees.
Lime punning	Lime punning consists in finishing interior sand plaster with a thin 3 mm thick coat of a carefully prepared pulpy mixture of one part of shell lime with three parts of stone lime.
Loam (दुमट)	A rich soil consisting of a mixture of sand and clay and decaying organic materials
Lock (ताला)	a device for securing a door, gate, lid, drawer, or the like when closed, consisting of a bolt or system of bolts propelled and withdrawn by a mechanism operated by a key, dial, etc.

	Padlock – is a detachable lock; a detachable lock; has a hinged shackle that can be passed through the staple of a hasp or the links in a chain and then snapped shut
	Mortise or mortise lock – a lock that is fitted in to the hole of wood, not that is screwed onto the surface.
	Rim lock – any lock body of which is attached to the inside face of a door.
	Latch – Spring-loaded door-lock that can only be opened from the outside with a key or catch for fastening a door or gate; a bar that can be lowered or slid into a groove. Or a type of lock on a door that can only opened from the outside with a key.
	Night latch – a door-lock operated from the inside by a knob and from the outside by a key.
	Time lock – a lock, as for the door of a bank vault, equipped with a mechanism that makes it impossible to operate within certain hours.
	Double lock – to lock with two turns of a key, so that a second bolt is engaged
	Combination lock – a lock opened by rotating one or more dials through a set of positions in a prescribed order and direction.
Longitude (रेखाशं, देशान्तर)	The distance east or west measured from some standard meridian, as that of Greenwich, England.
Louver (झिलमिली)	A window designed for ventilation, having slats, sloped to admit air and reject rain.
Masonry	Structure built of stone or brick by a mason (properly bonded together with mortar).
Mildew (फफूँदी)	A tiny white fungus that grows on plants, leather, food, etc in warm damp condition
Mitre (किरीट)	When bevel at 45^{o}, it is frequently called a 'mitre'. The surface of a bevelled end of a piece where a mitre joint is made Joint that forms a corner; usually both sides are bevelled at a 45-degree angle to form a 90-degree corner
Mortar	A mixture of cement, fine aggregates and waters
Mosaic (पच्चीकारी)	A design or pattern composed of many different individual items; a picture or pattern made by placing together small pieces of glass, stone, etc. of different colours.
Mullion (बिचला छड़)	1. A non-structural vertical strip between the casements or panes of a window (or the panels of a screen) 2. A large vertical division of a window opening. In grouped windows, the member, that separates the different units.

Moorum	Moorum is a decomposed laterite (Porous red soil common in southern India), deep brown, or red in colour and usually occurs in, or close to, laterite quarries.
Pelmet	A strip of wood, cloth, etc. placed above a window to hide a curtain fixtures and rail.
Pointing	Filling up joints in brickwork
Polyvinyl chlorides	A polymer of vinyl chloride used instead of rubber in electric cables. It is also known as PVC or vinyl resins are thermo-plastic resins.
Portland cement	It was invented in 1824 by Joseph Aspdin, and is so called because a paste of the cement with water, after it sets hard, closely resembles in hardness and appearance, a kind of compact grey sandstone found in Portland (U. K).
Raking	Removing mortar from the masonry joints to provide key for plastering/pointing.
Rebate	Step shaped grove. A rectangular groove made to hold two pieces together.
Screed	An accurately levelled strip of material placed on a wall or floor as guide for the even application of plaster or concrete
Sewer (मोरी)	A closed drain carrying night soil and other water borne waste
Shackle (कुण्डा)	A U-shaped bar; the open end can be passed through chain links and closed with a bar
Shellac (चपड़ा)	A flake material made from the secretion of the Lac insect. This flake shellac when cut with alcohol is known, both as shellac and shellac varnish; white or orange are the usual colours. The resinous shellac is obtained from the bark of a tree by distillation.
Shingle (कंकड़)	Shingles are, coarse beach gravel of small water-worn stones and pebbles (or a stretch of shore covered with such gravel) found in riverbeds.
Silt	A fine-grained soil with little or no plasticity
Soil (waste disposal)	The discharge from water closets, shop closets, and urinals
Soil pipe	The pipe, which receives the discharge from the soil fitment, such as water closets is called soil pipe. Urinals and slop sinks.
Storey or story (तल्ला, मंजिल)	An informal unit of distance equal to the average distance between floors of a building. In British English the spelling is "storey" and the plural is "storeys"; Americans write "story" and "stories." Typically a story equals 10 to 12 feet (3.0-3.6 metres). The origin of this use of the word "story" is not entirely clear, but in medieval times a tier of sculptures or stained glass windows on the front of a cathedral was called a stor(e)y because it usually told a story, and the number of stories was a measure of the size of the building.

Stucco	A plaster now made mostly from Portland cement and sand and lime; applied while soft to cover exterior walls or surfaces .Stucco is a decorative plaster superior to lime punning, used on both exterior and internal walls. It resembles white marble in finish and elegance.
Sullage	Waste water from bathrooms, lavatories, basins, kitchens, street and roof washings, etc.
Surface water	The rain water run-off from roofs paved areas, paths and roadways
Tar (डामर, तारकोल)	It is a dark black, viscous liquid. According to its source, tar is divided into three classes, - coal tar, and wood tar, mineral tar etc.
Tarpaulin (तिरपाल)	It is strong linen or hempen cloth coated with tar or pitch or rubberised to render it waterproof.
Template	A block of stone or concrete bedded on a wall to distribute the pressure from a concentrated load (also known as bed block). Alternatively, a pattern of sheet metal used as a guide for setting out specific section and shape.
Terrazzo (दाना)	Chips of polished stone set in concrete and used as floor covering
Tessellated	(Of a pavement) made from small flat pieces of stone of various colours arranged in a pattern.
Transom (आड़ा शहतीर, सरदल)	1. A window above a door that is usually hinged to a horizontal crosspiece over the door 2. A horizontal crosspiece across a window or separating a door from a window over it 3. A small window over a door or other window
Transom bar	The horizontal member, which divides an opening into two parts usually between top of a door and a transom above
Trass	rock used in cement-making: a light-coloured volcanic rock tuff used in making cement and mortar
Waste water	The discharge from lavatory basins, baths, bidets and sinks.
Weathering	A slight slope or fall given on the upper surface of cornices, copings, sun-shades, window sills, etc, to throw off the rain-water; action of sun and rain on structures or soils.
Whiting	Pulverised chalk; when mixed with oil into a paste form, it becomes putty.
Window sash	A framework that holds the panes of a window in the window frame
Woodblock	Each of the small pieces of wood used in making a floor, often arranged in a pattern.
Wrought	The term wrought carries the same meaning as planed (for woodwork and joinery).

Parts of a building

Attic (अटारी)	Attic is space between the roof and the ceiling of the upper story. In classical structures, that part which extends above the level of the cornice is called an Attic.
Balcony (छज्जा, बारजा)	A platform with a wall or rail built onto the outside wall of a building and reached from an upstairs room.
Ceiling (छत नीचे से या अंदर से)	The top inner surface of a room
Chhajja	A flat piece of cement or stone that projects from a wall above a window is called 'chhajja' or sun shade. The projected reinforced cement concrete member of average thickness not to exceeding 100 mm
Corbel (टोडा)	A bracket or support: a stepping out of a course in a wall to form a ledge
Cornice (छजली)	The projection at the top of a wall
Corridor (गलियारा)	A passageway in a building usually having rooms opening upon it
Courtyard (आँगन)	A space without roof but enclosed by walls forming part of a large house, etc.
Cubicle	A small room made by separating off part of a larger room. Cubicles are used for dressing or sleeping in.
Cupola	A small dome forming a roof or part of a roof. A roof in the form of a dome
Dado	Ornamental border round the lower part of wall of room The lower part of the wall of a room, when it is different from the upper part in colour or material or ornamental border round the lower part of wall of room
Drawing room	A room in a private house, in which people relax and guests are received and entertained
Facade	The face or front of a building
Fascia or facia	A board, etc above the front entrance of a shop, with name of the shop on it
Flat roof	A roof, the pitch of which is less than 10 degree to horizontal
Foundation	That part of the structure, which is in direct contact with and transmitting load to the ground.
Gable (त्रिअंकी)	Gable is the triangular upper part of the side or end of a building, under a sloping roof.
Garage	Portion of building in which to keep one or more cars, vans, etc.
Garret	A room, often small, dark, and unpleasant on the top floor of a house (in the roof)
Ground floor	The first floor above the ground level, usually the main floors
Inglenook	A space on either side of a large fireplace where one can sit.

Jamb	The part of the wall at the side of an opening
Patio (आँगन)	An outdoor area with a hard surface next to a house, where people can sit
Porch (ड्योढी)	A covered entrance to a building
Portico (मण्डप, ड्योढी)	A roof supported by columns, especially one forming an entrance to a large building.
Reveal	The visible part of each side of a recess or opening of a wall
Roof	A structure covering or forming the top of a building
Room	A portion of space within a building that is enclosed or partitioned off from other parts
Room	Room, is a part of a building, that has its own walls, floor, and ceiling and is usually entered from inside the building.
Sanctum	A private room, office, etc. where somebody can go and not be disturbed
Scullery (बर्तन मांजने की जगह)	A small room (in large old British houses) next to the kitchen; where kitchen utensils are cleaned and kept and other rough household jobs are done
Shoebox	A very small room in which to live or work
Site (plot)	A parcel (piece) of land enclosed by definite boundaries
Sub structure	That part of any structure, which is below, ground, in particular the foundations.
Suite	A set of rooms in a hotel, etc.
Super structure	The visible part of a structure; that above the sub structure
Vestibule (प्रकोष्ट, बरसाती)	1. A large entrance or reception room or area 2. An entrance hall, e.g., where hats and coats may be left
Wall	Any of the upright sides of a building or room are called 'wall'. A continuous upright solid structure made of stone, brick, or concrete used for enclosing, dividing, or protecting something.

Composition of a house

Anteroom	A room that admits to a larger room or a waiting room
Back room	A room in the rear of a building
Cell	A very small room
Cellar	The room or rooms below the main portion of the building are called 'cellar'. The depth of a cellar is, all or in part, below ground level.
Closet	A small room or cupboard for storing things
Closet	a small room, enclosed recess, or cabinet for storing clothing, food, utensils, etc.
Day room	A room at an institution, as a hospital or military base, with facilities for leisure activities
Dining room	Dining room is a room in which meals are eaten.

Drawing room	A formal reception room, esp. in an apartment or private house
Dressing room	A room in which to get dressed, esp. one for performers in a theatre, television studio, or the like
Family room	A room used for family activities
Foyer	The lobby of a apartment house, hotel, or theatre
Foyer	A vestibule or entrance hall in a house or apartment
Front room	A living room or parlour
Hall	A space or corridor/passage inside the entrance or front door of a building A building or large room for meetings, meals, concerts, etc The large entrance room of a house or building; vestibule; lobby A large room or building for public gatherings; auditorium: a concert hall
Hutch	A small or dark room; a place for storing. Small crude shelter used as a dwelling
Kitchen	A room or place equipped for cooking or preparing food.
Ladies room	a public lavatory for women
Larder	A small room used for storing foods or wines.
Living room	A room in a private house for general use during the day
Living room	A room in a home used by the members of the household for leisure activities, entertaining guests; parlour
Lobby	Large area inside the main entrance leading to other rooms
Locker-room	Characteristic of, or suitable to conversation in a locker room; earthy or bawdy: locker-room humour.
Loft	A room or space directly under the roof of a house used storing things.
Loggia	A room or gallery with one or more open sides, especially one that forms part of a house and has one side open to the garden
Lounge	A comfortable room in a private house for sitting and relaxing in.
Mezzanine	A gallery like floor, usually midway between the ground floor and the one above it.
Mud room	A vestibule or other area in a house, in which wet and muddy clothes or footwear are removed.
Office	A small room in which a particular person works
Outhouse	Outhouse is an outbuilding serving as a toilet; privy.
Pantry	A room or closet, usually near a kitchen, in which food, silverware, dishes, etc., is kept.
Powder room	Lavatory containing only a toilet and washbasin
Privy	A room or building equipped with one or more toilets Privy is a toilet, especially an outdoor one. [Private- assigned to private uses.]

Rooming house	A house with furnished rooms to rent
Sitting room	A room in a private house for general use during the day
Sitting room	A small living room
Toilet	"Half bath" means a room with toilet and sink: water closet (WC), flush toilet; latrine, lavatory, washroom, rest room
Utility room	A room, esp. in a house, reserved for a washing machine, furnace, or other large appliances.
Veranda	Veranda is a platform with an open front and a roof, which extends along the side or sides of a house; or an open portico extending along the outside of a building also called veranda. A porch, usu. roofed and partly enclosed, extending across the front and sides of a house.
Water closet	Private; secluded (WC)

Where man lives or works

Abode	(आवास, निवास) Place of residence. A place where one lives
Accommodation	One or more rooms, especially for living
Apartment	A set of room
Apartment house or block	A tall building with flats on each floor
Auberger	(सराय)A hotel providing overnight lodging for travellers
Barracks	A large building or group of buildings for soldiers to live in.
Billet	A place often a private house, provided for soldiers to live in temporarily especially during war.
Building	A structure with a roof and walls
Bungalow	A one-story house with veranda; sometime the attic is finished as a second storey. One storied house, sometimes with a veranda.
Camp	Place where people live temporarily in tents or huts.
Castle	Large building or group of buildings with thick walls and towers
Chalet	A type of mountain hut or house built of wood with a roof that slopes down over the sides.
Chateau	A large country house in France
Cottage	Small simple house with a single story, villagers' dwelling
Dak bungalow	A house in which government officials and others can stay while on tour
Den	A room in a home where a person can work (an animal's hidden home)
Dharamashala	A building where people can rest on a journey, especially one for pilgrims
Dormitory	A room for several people to sleep in (A large sleeping room containing several beds)

Duplex	1. A house with two units sharing a common wall 2. An apartment having rooms on two floors that are connected by a staircase 3. A building divided into two homes or semi detached house.
Edifice	Large important building that has a roof and walls and stands more or less permanently in one place
Flat	A set of rooms for living in including a kitchen, usually on one floor of a building
Fort	Place of defence.
Garden house	A house away from the city typically owned by rich people and used for entertaining guests or for holidays.
Gazebo	A small building designed to give a wide view of the country around.
Home	Home is the place where one lives, especially with one's family. One's dwelling place
Hostel	Residence for students
Hotel	A building where travellers can pay for lodging and meals and other services
House	House is a building made for people to live in. usually for one family.
Hut	Small roughhouse
Igloo	A small house with the roof in the shape of a dome, built by Eskimos from blocks of hard snow as a temporary shelter
Inn	A hotel providing overnight lodging for travellers
Inspection bungalow	A house in which government officials can stay while on tour
Lodge	Lodge is a house in which people can rent rooms for living. A small house at the gates of a park or in the grounds of a large house, often occupied by a gatekeeper or other employee.
Maisonette	An apartment, usually with rooms on two floors
Mall	A public area set aside as a pedestrian walk Mercantile establishment consisting of a carefully landscaped complex of shops representing leading merchandisers; usually includes restaurants and a convenient parking area; a modern version of the traditional marketplace
Manor	A large country house surrounded by an estate (Manor house)
Mansion	A large and impressive house
Mausoleum	An ornamental building made to hold the dead body of an important person or the dead bodies of a family.
Office	Place of business, service. or a room, set of rooms or building use as a place of business, especially for administrative work
Outhouse	A small building e.g. a shed, outside the main building (Outbuilding)
Palace	Royal or grand house

Penthouse	A house or a flat at the top of a tall building
Piazza	A public square with room for pedestrians
Pied-a-Terre	A small flat, usually in town that one does not live, as one's main home but keeps for use when necessary. Lodging for occasional or secondary use
Plaza	1. Plaza is a public square (open place). A small shopping centre
Premises	A house or an office together with any building or land near to it that are owned by the same person or company
Residence	Place where one dwells.
Rest house	A house in which government officials and others can stay while on tour
Retiring room	A room that can be rented by travellers at a railway station
Rooming house	A building where rooms with furniture in can be rented
Rotunda	A round building or hall, especially one with a curved roof
Semi-detached	(Of a house) joined to another house by shared wall.
Shanty or shack	A roughly built hut or shed.
Shed	A small simple building made of wood or metal used for storing things or sheltering animals, vehicles, etc.
Shelter	A structure built to give protection from weather or from attack.
Skyscraper	A very tall modern city building with many storie
Tower	A tall narrow building or part of a building
Villa	Country house with a large garden

Composition of country

Cantonment छावनी	A small town or part of one, originally built for military use.
City (नगर, शहर)	A large and important town
Colony (बस्ती)	A small town set up by an employer or an organisation for its workers. A place where a group of people with the same interest or occupation are concentrated
Country (देश)	An independent geographical area with its own government An area of land that forms a politically independent unit; a nation; a state
Country	Any area out side large towns and cities typically with villages, fields, woods.
District (जिला)	An area of a country or town treated as an administrative unit.
Estate	A large landed property.
Hamlet (पुरवा)	A very small village
Metro city	A large or capital city

Metropolis (महानगर)	The chief city of a region or country; a capital A large and densely populated urban area; may include several independent administrative districts
Town (शहर, नगर, कसबा)	Place with many houses, shops and other buildings that is larger then village but smaller than a city.
Urban centre	A large and densely populated urban area; may include several independent administrative districts
Village (गाँव)	Village is a group of houses, shops, etc. situated in country district. A smallest unit of local government. A settlement smaller than a town
Ward (हलका)	A division of a city, etc that elects and is represented by a councillor or local government (Hindi – Mohalla)

Cement

History of ACC cement

In 1936, ten cement plants belonging to four groups were merged to form India's no. 1 Cement producer – the Associated Cement Cos. Ltd (ACC). Today, ACC is a pioneer, meeting excellent standards, supplying bulk cement and ready mix concrete. It is new cement plant at Wadi in Karnataka, is the largest one in country.

ACC Suraksha is new eco-friendly, specially blended cement, produced by inter-grinding higher strength ordinary Portland cement clinker with high quality processed reactive silica. This feature makes ACC Suraksha a value added product that is not found in ordinary cements. It can be used for any kind of construction activity – commercial/ residential, bungalows/ complexes and all RCC jobs like foundation/columns/beams/that last for generations.

Varieties of cements

Natural cement		Natural cement is not much used in India.
Artificial cement	1. Portland cement	Ordinary Portland cement
		Portland Puzzolana cement
		Rapid hardening cement (high-early strength cement
		Low heat cement
	2. Special cement	Quick setting cement
		Calcium chloride cement
		High-Alumina cement
		Blast furnace slag cement
		White Portland cement
		Coloured Portland cement
		Acid-resisting cement

The percentage of lime in cement is 50%.

Gypsum is added to cement clinker to decrease the rate of setting of cement.

Blended cement

Blended cement volumes, which includes Portland pozzolana cement (P P C) and Portland slag cement (P S C). Blended cement contains far lesser share of clinker, a more expensive raw material, which is substituted by either fly ash (Portland pozzolana cement) or slag (Portland slag cement).

Ordinary Portland cement (O P C) on the other hand, is relatively higher cost cement, comprising around 95 % clinker, and small quantities of gypsum.

Cost of production of blended cement is cheaper by Rs 10 per bag (as in 2001).

Ordinary Portland cement

Portland cement or ordinary Portland cement, so called since about 1820 when it was first invented in England, because when hard it resembled the stone from Portland in Dorset. Roman cement was its forerunner.

Portland cement is manufacture by heating to clinker in kiln slurry of clay and crushed limestone. This is the cheapest and most widely used cement in building in India for all general purposes.

Portland pozzolana cement

A cement made by adding about 20% of finely ground burnt clay or shale to Portland cement so as to combine with its free lime and reduce its liability to leaching by aggressive water such as that containing sulphates or to increase its fire resistance. It hardens more slowly than Portland cement but reaches the same final strength. (Pozzolana OR Puzzolane or Pozzuolana: - Volcanic dust used at Pozzuoli, Italy, as hydraulic cement when mixed with lime. It can be made artificially by burning and grinding clay or shale).

Rapid hardening Portland cement

Rapid hardening or High Early-strength cement is cement, which is more finely ground than the ordinary Portland cement, and is therefore slightly more expansive. It also has slightly higher lime content and for these reasons develops its strength more quickly.

Low heat Portland cement

Low heat cement is cement with low initial heat liberation on setting, obtained by altering the chemical composition of ordinary Portland cement. Such cements with low lime contents are used for pouring thick masses of concrete such as dams in which the temperature may take many months or years to fall to that of the surroundings.

Quick setting cement

Quick setting cement is one in which the initial set starts within five minutes and the final set takes place within 30 minutes. Quick setting cement contains less gypsum and is ground much finer than ordinary Portland cement.

Portland blast-furnace cement

Cement made by grinding not more than 65% of granulated blast furnace slag with at least 35% of Portland cement. The resulting cement is used for making the concrete in dams since it has a lower heat of hydration and resists leaching better than Portland cement. It is not so strong at early ages, but his is unimportant for dams since the load is never put on at an early age.

High-alumina cement

High alumina cement is also known as Aluminous Cement, Fondu, or Cement Fondu

High-alumina cement is chocolate-coloured cement with higher Alumina content than Portland cement. It hardens sufficiently for normal loads in 24 hours and gets very hot during this period. So that when large masses pf it are needed it must be poured in thin layers, allowing each some time to cool before pouring the next layer. It is very resistant to attack by sulphides and acids and is much more refectory but costs about twice as much as Rapid Hardening cement.

Acid-resisting cement

Acid-resisting cements are silicate based cements one brand known as 'Natson's Cement ST-SS' made by Natson Manufacturing Co. (Mumbai) resists the action of all acids except hydrofluoric Acid.

Waterproof mastic cement

1 part red lead to 4 parts ground lime to 5 parts sharp sand mixed with boiled oil OR

One part red lead with five parts of whiting and 10 parts of sharp sand mixed with boiled oil.

Setting of cement

The setting of hydraulic lime and cement takes place in quite different way. The water added to hydraulic lime or cement enables the alumina and silica present to combine with the lime and form complex hydrated silicates and aluminates, which crystalline into hard solids. While the setting of pure lime is facilitated by dry conditions that of hydraulic lime or cement is favoured by the presence of water.

Which cement to use

In fact, all types of cement are one and the same but for minor changes in the characteristics. Largely grade-33 cement would meet the structural requirement of ordinary and small-scale consumers. 43-grade cement may be utilised for pre cast concrete, 53-grade cement may be utilising for heavy infrastructure such as bridges, flyovers, and high-rise structures.

The common man's perception that 53-grade cement is the best cement is not only due to the aggressive marketing strategies of the cement manufacturers but also on the presumption that the heat generated during hardening is an index of its quality, when 53-grade cement is used the heat generated is very high. Hence the consumer believe that it is better cement when actually it is not so. Each grade of cement has to be chosen for a particular use.

While 53-grade, cement is actually best only for producing concrete of grade-53 and above. It is not to be used in ordinary structures where concrete grade- 20 (M-20) is normally adequate.

The total decontrol and the competition amongst manufacturers and the market forces have actually eliminated 33-grade in the market.

Each of cement has its own role to play and there is no reason to believe which cement is superior to the other cement. For ordinary structure, Ordinary Portland Cement (OPC) grade-33 cement could meet the requirement. For producing concrete of higher grades, mixes have to be designed using OPC. For non-structural uses such as masonry and plastering mortar, cement much low in strength than OPC 33-grade, classified, as masonry cement is the best suitable material. However, unfortunately, no manufacturer produces this type of cement.

The control exercise in production concrete in regard to the selection and proportioning of materials, use of the minimum required quantity of water, careful handling of the mix during transportation and placing, compacting well to get a dense concrete, having an engineered form work, continuous curing and the like contribute greatly to the quality and durability of concrete.

Indian standard Specifications

Type of cement	**Indian Standard**	**Grade**	**Where to use**
Portland Pozzolana Cement (PPC)	I S -1489 (Part I): 1991	-	All normal construction works
Portland Pozzolana Cement (PPC)	I S -1489 (Part II): 1991	-	marine & under water 'solid concrete structures
Portland Slag Cement	I S -455: 1989	-	All normal construction works specially used for marine works
Ordinary Portland Cement	I S -269: 1989	S- 33	All normal construction works specially suitable for masonry and plaster work
Ordinary Portland Cement	I S -8112: 1989	S- 43	All normal construction works specially suitable for high strength concrete works
Ordinary Portland Cement	I S -12269: 1989	S- 53	Precast concrete high rise structures, bridges

ISI mark is must for cement

Facts about Portland cement

1. Portland cement improves by age, if kept from moisture.
2. The longer it is in setting, the strongest it will be. At the end of a year, 1 part cement to 1 part sand is about ¾ the strength of neat cement; 1 to 2 about ½ strength; 1 to 3 about ⅓; 1 to 4 about ¼; 1 to 5 about ⅙.
3. Strong cement is heavy, blue-grey, and slow-setting.
4. The less water used in mixing up the cement the better
5. Quick setting cement has generally too much clay in its composition—is brownish and weak.

6. Cement setting under still water will be stronger than if kept dry.
7. Salt water is as good as fresh water for mixing cement.
8. Lime in cement should not exceed 62% or be less than 52%.
9. Cement rich in lime is not able to stand the action of seawater.
10. If used in seawater, it is advisable to mix the cement with Puzzolana or slag cement, trass, ground slag, or brick, to form fresh hydraulic mortar with any excess of lime.
11. While testing crushing strength, about ⅝ of the crushing weights produces the first crack.
12. Portland cements when added with calcium chloride it becomes rapid hardening.
13. Pozzolana or slag cement, which contains 30-50% TRASS added to Portland cement.
14. 'Portland' and 'Alumina' cement should not be allowed to meet with each other.
15. Limestone should be avoided in constructions to be fire proof.
16. Volumes of fines should be slightly in excess if rocks are coarse materials.
17. Bricks, stones, etc, used with cement should be soaked
18. Blocks of brickwork or concrete should be kept in water until required for use.
19. The cleaner and sharper the sand the greater the strength of mortar and concrete
20. Cement should not be used neat except as cement wash or to make a joint required having a very smooth finish such as joint of the outlet of a water closet pan to soil pipe or drainpipe.

Difference between White Cement and Wall Putty?

Wall putty is white cement based, added with some dispersible polymers (expansive materials) -that gives you more coverage. It gives a very fine finish, so primer is a must before painting. It imparts a solid bond with primer and gives a lustre, perfect finish, rich look to the paints of walls - which make it's compulsion for very costly paints. But it has no waterproofing capacity - do not use for exterior surface even if the producers advertise for it. It can be applied to both wet and dry wall but advisable to use on dry surface.

White cement can be effectively used just like lime wash or a thicker paste (generally called putty) to achieve more smooth surface can be used on only dry surface - that fills unevenness of walls, effective waterproofing. Due to its cementing property, bonding with wall is very good, being due to somewhat coarse finish than putty, does not require a primer before painting. It can be used for both interior as well as exterior surface for a good finish and generally used.

White cement (in a liquid paint form) be applied on the wall before the first coat of putty to increase the life and reduce the cost of putty.

Field tests for cement

Purity and quality of unknown or doubtful cement can be judged by applying the following field tests: -

1. The colour of the cement should be uniform and characteristic cement grey (with a light greenish shade).
2. To test, if it is spoilt by air setting, any lump found in the cement must not be so hard that it cannot be pulverised by pressing between the thumb and the forefinger.
3. It should feel smooth to touch and neither rough nor gritty; roughness or grittiness would indicate adulteration with sand or sandy clay.

The strength of cement can be roughly judged by making briquettes of size 3 inch × 1 inch × ½ inch with a lean i.e. weak mortar (say one part cement to six parts sand).

Gripping them horizontally at one end and breaking them, after 3 days immersion, with steadily, increasing transverse load applied at the free end; if the cement is sound, the briquette should not be friable or easily broken.

Stacking & preservation of cement

Provide suitable dunnage to store the cement to prevent ground moisture.

Cement is to be stacked away from the walls. Protective top cover is to be provided.

Stacks should not, if possible are more than seven or eight bags high. When accommodation is limited, stacks may be up to 15 bags high provided they are stacked in header and stretcher fashion.

Place cement bags close together in a pile to reduce circulation of air as much as possible.

Do not disturb or re-stack cement until it is taken out for use, when the bags should be rolled to remove "***Warehouse Pack***."

Strength of stored cement

Fresh	= 100 %		After 1 year 3 months	= 65 %
After 3 months	= 80 %		After 1 year 6 months	= 60 %
After 6 months	= 75 %		After 1 year 9 months	= 55 %
After 1 year	= 70 %		After 2 years	= 50 %

Effect on strength on concrete

If storage conditions are not perfect, cement stored for long periods generally adversely affected. Table below gives general idea of reduction in strength of concrete made with stored cement:

Period of storage of cement	**Minimum expected reduction in strength at 28 days**
Fresh	0 %
3 months	20 %
6 months	30 %
1 year	40 %
2 years	50 %

Above values are approximate. Whenever a doubt is felt a sample of cement should be got tested from a recognized laboratory to ascertain, whether the strength and setting properties have been severely affected.

Shrinkage of cement & mortars

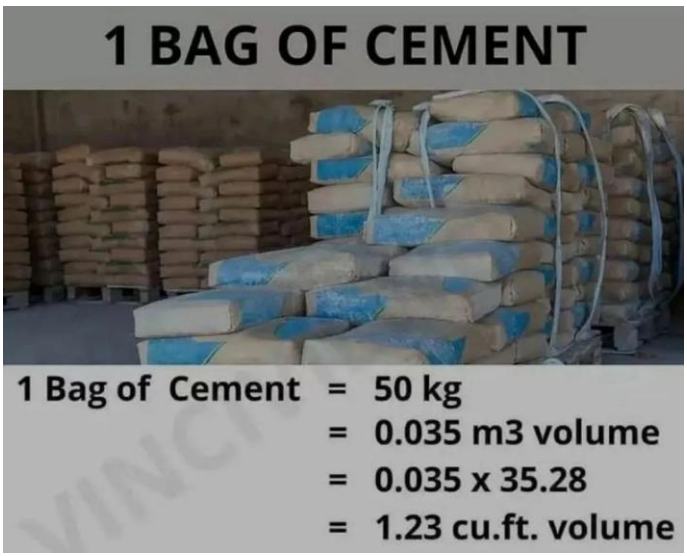
Cement shrinks when wetted	15 to 30 %
Dry mix of cement and sand in various proportions shrinks	25 to 35 %
Dry mix of cement concrete in various proportions shrinks	20 %
Sand shrinks when wetted	20 to 30 %

Measurement of cement

Rapid hardening cement =1 cu ft =36.5 Kilograms =80 Pounds
Ordinary Portland cement =1 cu ft =41 Kilograms =90 Pounds
Ordinary Portland cement =1.24 cu ft =50 Kilograms =1 Bag
Ordinary Portland cement =24 cu ft =1 Metric ton =20 Bags

Size for measuring box for 50 kilograms cement bag

40 cm × **35** cm × **25** cm =0.035 cum = 1.24 cu ft



Quantities of materials

Mortar mixes

Ratio	Cement	Sand	
1:1	1058.83 Kilogram (21bags)	0.73 cum	26 cu ft
1:1½	801.00 Kilogram (16bags)	0.83 cum	29 cu ft
1:2	699.05 Kilogram (14bags)	0.96 cum	34 cu ft
1:2½	570.00 Kilogram (11.4bags)	0.99 cum	35 cu ft

Ratio	Cement	Sand	
1:3	493.03 Kilogram (10bags)	1.00 cum	35 cu ft
1:4	382.33 Kilogram (7.64bags)	1.03 cum	36 cu ft
1:6	254.20 Kilogram (5bags)	1.04 cum	37 cu ft
1:8	192.70 Kilogram (4bags)	1.06 cum	37 cu ft
Quantities are for dry mix one cubic meter			

Lime mortar mixes

Ratio	Lime	Sand	Surkhi
1:1	377.00 Kilogram	0.72 cum	
1:2	255.00 Kilogram	0.95 cum	
1:3	193.00 Kilogram	1.07 cum	
1:1:1	255.00 Kilogram	0.48 cum	0.48 cum
1:1:2	192.00 Kilogram	0.71 cum	0.36 cum
Quantities: Per cubic meter			

Lime gauged mortar

Ratio	Cement	lime	Surkhi
1:1:1	634.00 Kilogram	235.00 Kilogram	0.86 cum
1:1:3	412.00 Kilogram	153.00 Kilogram	0.86 cum
1:1:6	240.00 Kilogram	97.00 Kilogram	0.98 cum
1:1:8	185.00 Kilogram	75.00 Kilogram	0.98 cum
1:2:9	161.00 Kilogram	125.00 Kilogram	0.98 cum
For mixes containing lime add 2 to 3% for wastages			
Quantities: Per cubic meter			

Concrete mixes

Ratio	Cement w/o wastage	Cement Including wastage	Sand	Aggregate
1:1:2	563.58 kilogram	577.67 kilogram	0.37 cum	0.74 cum
1:1½:3	393.00 kilogram	402.83 kilogram	0.41 cum	0.82 cum
1:2:2	417.00 kilogram	427.43 kilogram	0.58 cum	0.58 cum
1:2:3	351.00 kilogram	359.78 kilogram	0.49 cum	0.74 cum
1:2:4	301.00 kilogram	308.53 kilogram	0.42 cum	0.84 cum
1:2: 5	262.00 kilogram	268.55 kilogram	0.42 cum	0.84 cum
1:2½: 5	247.00 kilogram	253.18 kilogram	0.43 cum	0.87 cum
1:3:6	208.00 kilogram	213.20 kilogram	0.44 cum	0.88 cum
1:4:8	158.00 kilogram	161.95 kilogram	0.45 cum	0.90 cum
1:5:10	126.00 kilogram	129.15 kilogram	0.45 cum	0.90 cum
1:7:12	102.00 kilogram	104.55 kilogram	0.50 cum	0.95 cum

For any mix quantity of cement in cubic metre can be calculated by dividing 148, by the sum of the proportions of concrete mix

Cement constants

Constants are for volumetric mix & are inclusive of 2½% wastage. Quantity of cement is in kilograms

Description of item of work	Ratio	Unit	Cement
Mixed cement concrete delivered on banker.	1:1½:3	cum	402.83
	1:2:4		308.53
	1:2:5		268.55
	1:2½:5		253.18
	1:3:6		213.20
	1:4:8		161.95
	1:5:10		129.15
	1:7:12		104.55
Mixed cement concrete using all in aggregate delivered on banker.	1:5	cum	312.63
	1:6		264.45
	1:8		206.03
	1:12		138.38
Cement and sand mortar	1:1	cum	1058.83
	1:2		699.05
	1:3		493.03
	1:4		382.33
	1:6		254.20
	1:8		192.70
Gauged mortar (cement, lime and sand mortar)	1:1:6	cum	244.98
	1:1:8		189.63
	1:2:9		164.00
	1:5:10		147.60
	1:7:12		120.95

Description of item	Ratio	Unit	Old size bricks	Modular bricks
Brick work in well-burnt bricks straight on plan or to a curve, exceeding 6 mitres mean radius, built in cement and sand mortar.		cum	Cement	
	1:3		123.00	113.38
	1:4		95.84	87.96
	1:6		64.06	58.47
	1:8		47.93	44.32
Brick work in well-burnt bricks straight on plan or to a curve, exceeding 6 mitres mean radius, built in gauged mortar	1:1:6		60.48	56.82
	1:1:8		47.93	43.62

Description of item of work		Ratio	Unit	Cement
	1:2:9		40.49	37.72
Description of item of work		**Ratio**	**Unit**	**Cement**
Stone masonry: walling of random or polygonal rubble un-coursed or brought up to course well bonded, bedded, and solidly hearted in gauged mortar.		1:1:6	cum	73.80
		1:1:8		56.89
		1:2:9		49.71
10 millimetres (½ inch) thick rendering or screed on brick or concrete surfaces (or even face of walls) in cement and sand mortar and gauged mortar		1:2	sq m	11.79
		1:3		8.41
		1:4		6.77
		1:6		4.46
		1:1:8		3.38
		1:2:9		2.82
10 millimetres (½ inch) thick rendering or screed on stone masonry surfaces or lathing (or over uneven face of brick walls) in cement and sand mortar and gauged mortar		1:2	sq m	15.68
		1:3		11.17
		1:4		8.41
		1:6		5.64
		1:1:8		4.20
		1:2:9		3.64
Add to or deduct from 10 millimetres thickness of plaster for each 5 millimetres (¼ inch) thickness in cement mortar or gauged mortar over or less than 10 millimetres on concrete, brick, lathing or stone masonry.		1:2	sq m	4.47
		1:3		3.38
		1:4		2.51
		1:6		1.69
		1:1:8		1.38
		1:2:9		1.13
Raking out joints to a depth of 10 millimetres and flush keyed or struck pointing on brickwork, in cement mortar.		1:2	sq m	2.51
		1:3		1.69
		1:4		1.39
Raking out joints to a depth of 10 millimetres (⅜ inch) and flush keyed or struck pointing on stone masonry random rubble un-coursed or brought to course with 20 millimetres (¾ inch) joints in cement mortar.		1:2	sq m	5.02
		1:3		3.95
		1:4		2.83
Raking out joints to a depth of 10 millimetres (⅜ inch) and flush keyed or struck pointing on block in course or ashlars or concrete block walling in cement mortar.		1:2	sq m	1.39
		1:3		1.13
		1:4		0.85
Raking out joints to a depth of 10 millimetres and flush keyed or struck pointing on but squared rubble coursed or un-coursed walling in cement mortar.		1:2	sq m	3.95
		1:3		2.82
		1:4		2.26
Bastard tuck or mason's V-joint pointing to squared rubble coursed or		1:2	sq m	6.15

Description of item of work	Ratio	Unit	Cement
un-coursed masonry, in cement mortar.	1:3		4.46
	1:4		3.64
Hard-burnt brick floors laid flat, jointed, and pointed flush in cement and sand mortar.	1:3	sq m	11.17
	1:6		5.64
Finishing concrete floors fair and smooth with steel hand float using extra cement		sq m	1.38
Hard-burnt brick floors with bricks laid on edge, jointed, and pointed flush in cement and sand mortar.	1:3	sq m	15.68
	1:6		8.41
30 millimetres thick granolithic flooring	1:1:2	sq m	16.09
10 millimetres (⅜ inch) thick terrazzo flooring	1:1½	sq m	8.71
Brick floor laid on edge, jointed, and pointed in cement mortar (without ½-inch bedding layer).	1:6	sq m	5.11
	1:3		9.90
Brick floor laid flat, jointed, and pointed in cement mortar (without ½-inch bedding layer).	1:6	sq m	2.53
	1:3		4.90
40 millimetres (1½ inches) thick, brick tile in roof jointed and pointed in cement mortar (without ½-inch bedding layer).	1:3	sq m	2.45
50 millimetres (2 inches) thick, brick tile in roof jointed and pointed in cement mortar (without ½-inch bedding layer).	1:3	sq m	3.27
Honeycomb brickwork, built in cement mortar.	1:3	cum	24.50
	1:4		19.10
	1:6		12.70
	1:8		9.60
Bedding and haunching, salt glazed stoneware pipes 100 millimetres (4 inches) bore.	1:3:6	metre	14.85
	1:4:8		11.28
Bedding and haunching, salt glazed stoneware pipes 150 millimetres (6 inches) bore.	1:3:6	metre	23.76
	1:4:8		18.05
Bedding layer for tiling	10 sq m		0.07 cum
Jointing and pointing tiles with cement slurry	10 sq m		27.50 kg
Coloured cement for pointing any type of tile	10 sq m		21.00 kg

50 Kilogram of cement will make concrete

- 0.166 cubic meter (6 cu ft) of 1:2:4 concrete (approximately)
- 0.192 cubic meter (7 cu ft) of 1:2½:5 concrete (approximately)
- 0.250 cubic meter (9 cu ft) of 1:3:6 concrete (approximately)
- 0.333 cubic meter (12 cu ft) of 1:4:8 concrete (approximately)
- 0.400 cubic meter (14 cu ft) of 1:5:10 concrete (approximately)
- 0.500 cubic meter (18 cu ft) of 1:6:12 concrete (approximately)

Tools & plants for concrete work

Vibrator

It is a tool, which vibrates at a speed from 3,000 to 10,000 rotations per minute and is inserted into wet concrete or applied to the formwork to compact the concrete. Concrete vibrators are of various types.

For concretes cast in place

Internal vibrator

(Poker vibrator or immersion vibrator)

A cylinder of 25 to 75 millimetres in diameter contains a vibrating mechanism. It is inserted into wet concrete to compact it. These are the best-known type.

External vibrator

A vibrator for concrete placing fixed to the formwork. This method of vibration has the disadvantage that the shuttering must be usually strong, and it is therefore little used.

Surface vibrators

A vibrating machine fixed to a steel trough-type plate over steel springs. Two men moving up and down operate it over the concrete place over roof or floor slabs. This machine is so designed that poker vibrator can also be run by it when required.

Plate vibrator

A self-propelled mechanical vibrator with a flat base, used for compacting fill, which is to be built on.

For pre-cast work

Platform vibrators

Small vibrators carried by one or two men moving up and down a pile or lamppost

Table vibrators

This may vibrate vertically for heavy work or with rotary movements for light pieces.

For road slabs

A hand screed 12 feet long requires one vibrator, for greater lengths two vibrators are fixed on the screed.

For very large capacities

Concrete vibrating machines, which travels like the concrete-finishing machine or spreader and vibrates up to 30 cubic metre pf concrete per hour.

Concrete mixer

Concrete mixture is a machine, usually with a rotating drum in which aggregates, cement, and water are mixed for 2 to 3 minutes to make concrete. Mixtures are described by two figures such as 5½/3½ (100 litres), 7/5, 10/7 (200 litres), and 14/10 (280 litres), 22/14 (400 litres), and 45/28 (800 litres). Of these figures, the first, which is always the larger, is the capacity of the

mixture in cubic feet of damp aggregate and dry cement. The second figure is the volume of the aggregate, the cement after water has been added to it, and it has been mixed to a batch of concrete. Larger sizes than 14/10 are described by their output of concrete only.

Tilting mixer

A tilting mixer is a concrete mixer, which discharge its contents by tilting the rotating drum. It is a common small batch mixer standardized at 3½, 5, and 7 cubic feet.

Capacity of batch (concrete) mixer

MIX by volume	**Numbers of 50-Kg cement bag to produce batch of concrete of suitable size of mixers of different capacities litres (cu ft)**				
Litres →	**100**	**200**	**280**	**400**	**800**
Cu ft →	**5½/3½**	**10/7**	**14/10**	**22/14**	**45/28**
1: 1½: 2	¾	1½	2½	3½	6½
1: 2: 3	¾	1½	2	3	6
1: 2: 4	½	1	1½	2½	5½
1: 2½: 5	½	1	1½	2	4½
1: 3: 5	½	1	1½	2	4
1: 3: 6	½	¾	1	1½	3
1: 4: 8	-	¾	¾	1½	3

Aggregate

Fine aggregates

Sand or grit, which passes a sieve of mesh 4 millimetres (3/16 inch) square opening, is called fine aggregate

Surkhi

Pounding old bricks, brickbats, or clay balls burnt in kilns usually makes Surkhi.

Sand

Sand is a granular material (composed mainly of quartz) of 2 to 0.6 millimetres in size and may be rounded or angular. It has no cohesion when dry or saturated but has apparent cohesion when damp.

According to source, sand may be classified into the following categories:

Pit sand

River sand

Sea sand

Graded sand

Sand, which contains some coarse, fine, and medium sizes, is called graded sand. It may be well badly graded but is not uniform sand.

Fine sand

Fine Sand that is available in the market is a sand, most of whose particles are of uniform size. For obtaining good quality work, this sand is to be mixed with certain amount of coarse sand before use in the mortars.

Coarse sand

Coarse sand as available in the market is badly graded sand and it must at least to be sieved through 4-millimetres size sieve before use.

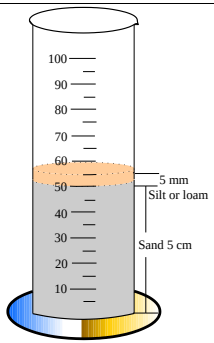
Good sand

Sand for making mortar or concrete should consist of clean, sharp, angular, durable grains, chemically inert and free from earthy matter and salts. Standard sand grains should pass through a sieve of 400 meshes per square inch and be retained on a sieve of 900 meshes per square inch. Rubbing the sand between fingers can test presence of earthy matter. Stained fingers indicate presence earthy matter.

Cleaning of sand

Sand containing earthy matter is done by washing it in a trough under a current of water, the mixture being well stirred, so that the flowing water removes the impurities and clean sand is left in the trough.

Testing of silt in sand



PERCENTAGE OF LOAM/SILT = (0.5 ÷5) × 100
Technically safe limit for silt is 5 to 6%
Silt if shaken in the palm of the hand, a part of saturated inorganic silt expels enough water to make surface appear glossy. If the part is pressed or squeezed between the fingers, its surface again becomes dull.

Bulking of sand

It is increase in volume of dry sand when its moisture content increases. This may amount to 40% when 5% water is added. This increase disappears entirely when water content is raised to 20

Phenomena of bulking

Sand is delivered and used on the job quite frequently contains moisture which causes film of water to form on the surface of the particles, fluffing them apart. This is called the bulking and moisture content of about 5% or 6% may be as much as 20, 30, or even 40% depending upon the grading of the sand, fine sand bulk much more than coarse sand. Further addition of water tends to flood or pack the sand decreasing the amount of bulking, and when the sand is completely inundated, the volume is approximately the same as when measured dry and loose.

If no allowance is made for bulking when batching by volume it will not only increase the cost of concrete by reducing the yield per bag of cement, but it will also have an under sanded mix which is harsh and difficult to place.

Test for bulking of sand

The test is because while the damp sand bulks, the volume of saturated sand-completely inundated with water- is the same as if the sand were dry. Thus, measurement of the saturated sand and the result will be the same as for dry sand.

To make the test, the following is require –

1. A straight-sided container such as a 1-kilogram capacity, clean empty can or jam jar.
2. A steel foot rule.
3. A steel rod to rod the sand with it
4. A second container to tip it into, and some water

Process

Step 1	First, fill the container about two- thirds full with the sand to be tested. Drop it loosely – do not pack it.
Step 2	Level off the top of the sand, and pushing a steel rule down through to the bottom, measure its height. Suppose it is 150 millimetres (6 inches). It is the height of the damp, bulked sand. Next step is to find the height of the same sand when saturated with water-which is the same as when dry.
Step 3	Empty the sand in the other container, taking care to see that none of it is lost in the process.
Step 4	Half fill the first container with water.
Step 5	Now put the sand back into the water bit by bit, so that it is entirely saturated.
Step 6	Put back about half of the sand and rod it thoroughly to remove any air. Then add the rest and rod again in the same way and level off the top.
Step 7	Now push the steel rule through the sand, as before and measure the new height-it will be noted that it has sunk. Say it now measures 125 millimetres (5 inches).

Applying the test

Therefore, we know that the sand which when saturated (or dry) measured 5 inches have bulked to 6 inches when damp. The bulking is, therefore, 1 inch on 5 inches of dry sand, that is to say, 20%.

In gauging sand for the mix, therefore, we should use 20% more than that quoted in the specification. Suppose the mix specified is (1:2:4), and then the actual quantity of sand to be used will be 1.2 × 2 = 2.4 Cubic metres giving a field mix of ratio (1:2.4:4).

What happens if we neglect to make this correction for bulking? The actual dry sand measured will be 1/1.2 ×2 = 1.67 Cubic metres. The mix will then be (1:1.67:4) in terms of dry sand. This reduction in the ratio of sand causes a reduction in the quantity of concrete produced with each bag of cement, and in most cases, there will be insufficient fine material to give a workable mix.

The bulking test should be made at the start of work, and after that on each new consignment of sand and after any material change in the weather-rain or hot sunshine- to ensure that the bulked volume of the sand is not changed. It may be noted that coarse aggregate is little affected in volume by water.

The coarser the aggregate, the less free water it will carry

Quantity of surface water carried by aggregates

Very wet sand	= 96 -128 Kilograms per Cubic metre
Moderately wet sand	= About 64 Kilograms per Cubic metre
Moist sand	= About 32 Kilograms per Cubic metre
Moist gravel or crushed rock	= About 32 Kilograms per Cubic metre

Approximate water absorption of aggregate

Average sand	=1.0 % by weight
Gravel and crushed limestone	=1.0 % by weight
Trap rock and granite	= 0.5 % by weight
Porous sandstone	=7.0 % by weight
Very light and porous aggregate may have absorption as high as	=25.0 % by weight

Functions of sand & surkhi

SURKHI: pounding old bricks, brickbats, or clay balls burnt in kilns usually makes Surkhi. Like sand, it is used as adulterant, but unlike sand, Surkhi imparts strength and hydraulic property to the mortar. To develop good hydraulic property, the Surkhi should be made from well-burnt bats, ground into very fine powder, and the mortar mixed well in mortar mill. [Surkhi is called trass or brick dust in England].

SAND in mortar do not add to its tensile strength but is used chiefly as an adulterant to save cost. It also prevents the shrinkage and cracking of mortar in setting. In good work, sand should be clean and free from clay and the grains should be sharp and angular.

Of late years careful experiments have shown that angular grains are not superior to round grains; whether this the case or not, the point is of small importance compared with that of obtaining a material which is free from any admixture of clay, loam, earthy and organic matter.

Coarse aggregate (or stone)

For concrete, aggregate which stays on a sieve of mesh 4 millimetres (3/16 inch) square opening.

Aggregate for concrete should not absorb water more than 10% of their own mass.

Size of aggregate in no case should be greater than one fourth of the maximum thickness of the member. For reinforced concrete work, aggregates having a nominal size of 20 millimetres are generally considered satisfactory.

Graded aggregate

Aggregate containing selected proportions of different particle sizes, usually chosen to form a concrete of maximum density.

Gap graded aggregate

Aggregate with which an attempt has been made to form a dense concrete by adding a proportion of sand or grit to the stone rather than by continuous grading, which implies adding material to bring all sizes to roughly uniform proportions. Excellent dense concrete can be made by both methods, but gap grading is usually easier in practice, since two sizes of aggregate are more easily combined than a large numbers.

Pebble

A small stone made smooth and round by the action of water, e.g. in a stream or by the sea.

Flint

Flint is a very hard grey stone that can produce spark of fire when struck against steel.

Fly ash

Fly ash from thermal plants can be profitably used to make bricks and pre-cast blocks.

Lime stone

Limestone, common type of sedimentary rock composed principally of calcite (calcium carbonate, $CaCO_3$). When "burned," or calcined (raised to a high temperature), it yields lime. Crystalline metamorphosed limestone is known as marble. Many varieties of limestone are formed by the consolidation of seashells, which are formed by the largely CaCO3 secretions of various marine animals. Chalk is a variety of porous, fine-grained limestone composed mostly of foramina-fera shells; coquina is a soft limestone made up of shell fragments. A variety of the rock, known as oölitic limestone, is composed of small spherical concretions, each containing a nucleus of a sand grain or other foreign particle around which deposition has taken place.

Lime

Lime is the product obtained by the calcinations of limestone (carbonate of lime $CaCO_3$), the effect of which to drive off the carbonic acid and moisture it contains. Chemically, lime is oxide of calcium (CaO).

When quicklime is treated with as much water as it will readily absorb, it almost immediately cracks, swells and falls into a bulky powder with a hissing, cracking sound, slight explosions and considerable evolution of heat.

Slaked lime is the white, powdery product formed by the absorption of water by quicklime. Slaked lime is hydrated oxide of calcium.

Quick lime	Pure lime is also called quicklime and it is the lime produced by the calcinations of a comparatively pure limestone
Fat lime	Pure lime does not set in water. It slakes vigorously; the increase in volume is 2 to 2½ times of the volume of quick lime.
Poor lime	Mixed with mud, sand, or other impurities, this does not alter its condition.
Slightly hydraulic lime	Containing 8 to 12% of silica, Alumina, magnesia, iron, and manganese sets slowly in water.
Hydraulic lime	Containing 12 to 20% of above sets in water in 6 or 8 days
Eminently hydraulic lime	Containing 20 to 30% of the above set in waters two to four days
Hydraulic cement	Containing 30 to 50% of argil sets in few minutes and attains the hardness of stone in a month.
Rough indication of limestone	They dissolve wholly or partially in weak acids, with brisk effervescence. They are nearly insoluble in water. They can be scratched with an iron point.
Puzzolana or trass	Volcanic product if mixed with pure lime makes hydraulic mortar.

Properties & classification of lime

Class	Known as	Used for
Class-A	Eminently hydraulic lime	Structural purposes
Class-B	Semi-hydraulic lime	Masonry mortar
Class-C	Fat lime	Finishing coat in plastering, white wash and with puzzolanic material for masonry work

Concrete plain/reinforced

Concrete**,** artificial engineering material made from a mixture of Portland cement, water, fine and coarse aggregates, and a small amount of air. It is the most widely used construction material in the world.

Concrete is the only major building material that can be delivered to the job site in a pliable state. This unique quality makes concrete most desirable as a building material because it can be

moulded to virtually any form or shape and provides for continuity of structural action. Concrete provides a wide latitude in surface textures and colours and can be adopted to many uses, including construction of highways and streets, bridges, dams, large buildings, airport runways, irrigation structures, breakwaters, piers and docks, sidewalks, silos and farm buildings, homes, and even barges and ships.

Other desirable qualities of concrete as a building material are its strength, economy, and durability. Depending on mixture of materials used, concrete will support, in compression, 703.07 or more kilogram per square centimetre (10,000 or more pounds per square inch). The tensile strength of concrete is much lower, but by using properly designed steel reinforcing, structural members can be made that are as strong in tension as they are in compression. The durability of concrete is evidenced by the fact that concrete columns built by the Egyptians more than 3600 years ago are still standing.

Composition

It is convenient to think of concrete in terms of two major components, paste, and essentially inert materials. The paste consists of Portland cement, water, and some air either in the form of naturally entrapped air voids or minute, intentionally entrained air bubbles. The inert materials are usually composed of sand (fine aggregate) and gravel, crushed stone, and slag (coarse aggregate).

When Portland cement is mixed with water, the compounds of the cement react to form a cementing medium. In properly mixed concrete, each particle of sand and coarse aggregate is completely surrounded and coated by this paste, and all spaces between the particles are filled with it. As the cement paste sets and hardens, it binds the aggregates into a solid mass.

Under normal conditions, concrete grows stronger as it grows older. The chemical reactions between cement and water that cause the paste to harden and bind the aggregates together require time. The reactions take place very rapidly at first and then more slowly over a long period. In the presence of moisture, concrete continues to gain strength for years. For instance, the strength of concrete may approximate 70.307 kilogram per square centimetre (1000 pounds per square inch) in a day, 316.382 (4500) in 7 days, 421.842 (6000) in 28 days, and 597.610 (8500) after 5 years.

Concrete mixtures are usually specified in terms of the dry-volume ratios of cement, sand, and coarse aggregates used. A (1:2:4) mixture, for instance, consists of one part by volume of cement, two parts of sand, and four parts of coarse aggregate. Depending on the applications, the proportions of the ingredients in the concrete can be altered to produce specific changes in its properties, particularly strength and durability. The ratios can vary from (1:1:3) to (1:2:4) and (1:3:5). The amount of water added to these mixtures is about 1 to 1.5 times the volume of the cement (see Water cement Ratio). For high-strength concrete, the water content is kept low, with just enough water added to preserve the ductility of the mix.

Concrete can be made to have any degree of water tightness. It can be made to hold water and resist the penetration of wind-driven rains. However, for special purposes, such as in constructing filter beds, concrete can be made porous and highly permeable. Concrete can also be

given a polished surface that is as smooth as glass. By using heavy aggregates, dense concrete mixtures can be made that will weigh 4005 or more kg/cum (250 or more lb/cu ft). Concrete that weighs only 481 kg/cu m (30 lb/cu ft) can be made by using special lightweight aggregates and foaming techniques. Forms consisting of such lightweight aggregates can be floated on water, sawed into pieces, or nailed to another surface.

For small jobs and minor repairs, concrete can be mixed by hand, but machine mixing insures more uniform batches and, therefore, superior performance. For most home repairs and improvements, for example with floors, walks, driveways, patios, and garden pools, the recommended portions are a 1:2:4 mix.

The aggregates should be clean and free of vegetable matter. All sand should pass through a sieve that has a 0.635-centimetre (0.25-inch) mesh. The size of the coarse aggregates depends on the thickness of the structure that is to be built. In building relatively thin sections, a small size of coarse aggregate should be used. At the other extreme, aggregates up to 15 centimetres (6 inches) or more in diameter are used in large dams. In general, the maximum size of coarse aggregates should not be larger than one-fifth of the narrowest dimensions of the concrete member in which it is used.

After exposed surfaces of concrete have hardened sufficiently to resist damage, they should be cured by sprinkling or ponding (covering) with water or by using moisture-retaining materials such as waterproof paper, plastic sheets, wet burlap, or sand. Special curing sprays are available. The longer concrete is kept moist, the stronger and more durable it will become. In hot weather, it should be kept moist for not less than three days.

Construction Techniques

Concrete is poured into place in a number of ways. For the footings of small buildings, the wet concrete is poured directly into trenches dug into the earth below frost level. Concrete for foundations and certain types of walls is placed between supporting wood or metal forms, which are removed after the concrete has hardened. In lift-slab construction, floors and roof slabs are cast at ground level and then raised by hydraulic jacks and fastened to columns at specified elevations. Slip forms are used to produce vertical shafts for silos and the cores of buildings. They are moved upward at a rate of 15 to 38 centimetres (6 to 15 inches) per hour while concrete and reinforcement are put in place. The tilt-up method of construction frequently is used for one- and two-story buildings. Walls are cast in place on the ground or on the previously laid concrete floor and tilted into position by machinery. The walls are joined at the corners or between panels with cast-in-place concrete columns. In a conventional highway-paving operation, concrete is placed between metal side forms. These forms double as rails on which the paving equipment moves. The newer slip-form pavers, however, requires no rails; it operates on treads and carries its own side forms with it. Machine and forms move forward as the concrete is placed, leaving one or more lanes of concrete pavement behind.

For certain applications, such as the construction of swimming pools, canal linings, and curved surfaces, concrete may be applied by the so-called shotcrete method. In shotcreting,

concrete is sprayed under pneumatic pressure rather than placed between forms. Often the use of shotcrete eliminates the need for formwork and permits placement of concrete in confined areas where conventional forms would be difficult or impossible to construct.

Air-entrained concrete is concrete in which minute air bubbles are intentionally entrapped by the addition of an admixture to the cement either during its manufacture or during the batching and mixing of the concrete. The presence of a properly distributed amount of these bubbles imparts desirable properties to both freshly mixed and hardened concrete. In freshly mixed concrete, entrained air acts as a lubricant, improving the workability and cohesiveness of the mix. It also reduces the need for fine material (sand) and makes it possible to obtain the desirable properties with a smaller amount of water.

Entrained air in hardened concrete dramatically reduces the scaling that might otherwise result from the use of chemicals to melt ice on roads and streets. It also prevents damage to pavements caused by freezing and thawing. The air bubbles function as minute safety valves, or expansion chambers, by providing room for the free water in concrete to expand harmlessly as freezing occurs.

Concrete Masonry

This term is applied to block and brick building units moulded of concrete and used in all types of masonry construction. Concrete masonry is used for load-bearing and no-load-bearing walls; piers; partitions; fire walls; backup for walls of brick, stone, and stucco facing materials; fireproofing over steel structural members; fire-safe walls around stairwells, elevators, and other enclosures; retaining walls and garden walls; chimneys and fireplaces; concrete floors; and many other purposes.

About 60 percent of all concrete masonry units are made with lightweight aggregates. Processed clays, blast-furnace slag, shale, natural volcanic aggregates, and cinders are the most commonly used. Masonry units most commonly used for walls, both below and above ground are 20 centimetre by 20 centimetre by 40 centimetre (8 inches by 8 inches by 16 inches) in size and laid horizontally. They are cored to reduce weight and to provide an insulating air space within the block technically known as Hollow blocks). New types of concrete masonry, such as split and slump block, are being used as facing in homes, commercial buildings, schools, churches, and municipal facilities. Grille walls, made of the many available types of block, are widely used in new and remodelled buildings and for landscaping.

Basic block types are fairly well standardized today. Specific types usually can be supplied for any construction without cutting or fitting. Special moulds are available for the production of patterned shadow effects on exterior and interior block walls. It is possible to supply virtually any colour or type of texture, including coloured, glazed block that has a smooth and highly impervious face.

Columns

Slenderness ratio

The effective height of a column divided by its radius of gyration, the value l/k in the formula for Euler's crippling stress. This is simplified for concrete, in which columns are usually rectangular and calculations are therefore based on the effective height divided by the least width. If this exceeds 15, the allowable stress is considerably reduced until, at 45, the allowable stress is zero.

For steel a slenderness ratio of 200 is often is allowed, and for timber about 150.

For brickwork, stone or mass-concrete walls, no greater ratio of effective height to breadth than 24 are allowed and usually 18 is the maximum.

Long column

Long column or strut, which fails when, overloaded, by buckling rather than by crushing. It is generally assumed in reinforced-concrete work that this will happen with columns, which are longer than 15 times their least dimension. For this reason the stress on a column is reduced as, its length increases.

Short column

A short column, which is so short that if overloaded it, will fail not by buckling but by crushing. For columns of this sort, the slenderness ratio does not need to be calculated except as a check, that it is less than the greatest allowed for a short column.

Reinforced Concrete or Ferro-concrete

Concrete used in most construction work is reinforced with steel. When concrete structural members must resist extreme tensile stresses, steel supplies the necessary resistance. It usually is used in the form of roughened steel bars or steel mesh embedded in the concrete to supplement its natural strength. Roughened or twisted bars are used to provide an interlock without slippage between the steel and the concrete so that stresses can be transferred between both components.

Pre-stressing of concrete has eliminated previous limitations on the spans and loads for which a concrete structure can be economically designed. The basic function of pre-stressing is to eliminate or greatly reduce the tensile stresses to which crucial areas of concrete structures are subjected. This object is accomplished by stretching high-strength steel to induce compressive stresses in concrete. The strengthening effect of compression in concrete acts like the horizontal squeeze that is applied to a row of books; when sufficient pressure is applied to the books at each end, compressive stresses are induced throughout the entire row; thus, although the centre volumes are unsupported, the books can be lifted and carried horizontally.

Compressive stresses are induced in pre-stressed concrete by either pre-tensioning or post-tensioning the steel reinforcement. In the pre-tensioning process, the steel is stretched before the concrete is placed. After the concrete has hardened around the tensioned reinforcement, the stretching forces are released. As the steel reacts to regain its original length, part of the tensile stresses are translated into compressive stresses in the concrete through the bond between the

concrete and the steel. In post-tensioning, the concrete is cast around, but not in contact with, un-stretched steel. The steel is stretched after the concrete has hardened by anchoring one end against the concrete and using hydraulic jacks to pull the other. After stretching, the second end also is anchored. The concrete in between the anchors is consequently highly compressed.

Mass concrete

Concrete without reinforcement is called Mass concrete.

Plain concrete

Concrete that is with no reinforcement to carry weight or bending forces but with light steel to reduce shrinkage and temperature cracking, generally about 0.2% of the volume of concrete.

Reinforced concrete

Concrete containing more than 0.20% by volume of reinforcement consisting of steel rods or mesh is called reinforced concrete. The steel takes all the tensile stresses (theoretically) so that the cracks, which always occur in concrete, do not appreciably weaken it. In good design, the reinforcement is sufficiently distributed so that the cracks are not conspicuous.

Anti-crack reinforcement

A close mesh of light steel rods or chicken wire placed just below the surface of concrete to reduce surface cracking.

Cracking in reinforced concrete

Cracking is always expected in reinforced concrete, since it has such a high shrinkage on hardening. Additional cracks will occur on the stretched side of a beam but reinforcement should be inserted sufficient in quantity and closeness to make the cracks invisible to the naked eye and very close together. A contraction or expansion joint is inserted; this will also reduce cracking near it.

Pre-cast concrete

Concrete beams, columns, lintels, Chhajja, piles, and parts of walls and floors, which are cast and partly matured on the site or in a factory before being lifted into their position in a structure. Where many of the same unit arte required, pre-casting may be more economical than casting in place, may give a better surface finish, reduce shrinkage of the concrete on the site, and make stronger concrete.

Vibrated concrete

Concrete compacted by vibration from an internal or external vibrator. It requires very much less water for effective placing than does concrete compacted by punning therefore it is much stronger. The formwork, however, must also be stronger when the concrete is to be vibrated.

Dense concrete

Concrete is regarded as dense (though not necessarily strong) if it weighs more than 1923 kilograms per cubic metre. If its density is over 2243 kilograms per cubic metre, it is often strong.

Vacuum concrete

Concrete poured into formwork fitted with a *vacuum mat*. The vacuum mat sucks out surplus water from the concrete as well as air and produces a dense concrete, well shrunk concrete from which the forms can removed for walls and other vertical faces in 30 minutes after beginning of process. The concrete reaches its normal 28-days strength in 10 days and has 25% higher crushing strength although it can be placed in a workable, sometimes sloppy condition. Saving in cement and formwork can thus be appreciable.

Vacuum mat

A stiff flat metal screen faced by a linen filtering fabric, the back of which can be kept under a partial vacuum by a vacuum pump connected to it through a hose. The linen filter makes a flat smooth surface and can be replaced by a patterned material when the surface to be processed in the upper side of a floor slab. A 7-Horse Power motor is required for keeping the vacuum of a 12 feet square panel of vacuum mat.

Mixes of concrete

Nominal mix of concrete

Grade	**Total quantity of dry aggregate by mass per 50 kg of cement to be taken as sum of the individual masses of fine and coarse aggregate**	**Proportion of fine aggregate to coarse aggregate**	**Quantity of water per 50 Kg of cement (max)**
	Kilograms	**by mass**	**Litre**
M -5	800	Generally 1:2 but subject to an upper limit of 1:1½ and lower limit 1:½	60
M -7.5	625		45
M -10	480		34
M -15	350		32
M -20	250		30

Volumetric mix

The proportion of a batch of concrete, mortar, or plaster usually described for mortar as 1:2:9, meaning one volume of Portland cement, 2 volumes of lime putty, 9 volumes of sand. For concrete, 1:2:4 means 1 volume of cement, 2 volumes of course sand, 4 volumes of coarse aggregate. This method of describing concrete mixes is not used on large jobs since the volumes of cement and sand are so variable, and weigh batching is preferred. The mix is then defined as so many kilograms of cement to so many kilograms of sand with so many kilograms of aggregate.

Crushing strength of cement concrete

Period	Strength
1 day old	11%
3 days old	33%
7 days old	67%
28 days old	100%
3 months old	140%
6 months old	155%
1 year old	165%

Crushing strength of concrete of mix 1:2:4 after 28 days is 150-kilogram/square centimetre.

Crushing strength of concrete of mix 1:1½:3 after 28 days is 200- kilogram/square centimetre.

Initial setting time

The time required before a concrete mix can carry a small load without sinking like a mud. This is about one hour in warm weather with wet concrete. However, with ordinary vibrated concrete or vacuum concrete, no impression with the full weight of the foot can be made immediately after vibration or vacuum treatment. Nevertheless, such concrete do have an initial set, which increases their strength in the same way as that of wet concrete. They have initially a much higher strength due to their lower water content.

Workability cement concrete

Workability of cement concrete will depend upon the following

- Shape of the aggregate (rounded or cubical particles gives better workability)
- Grading
- Proportions of aggregate
- Efficiency of mixing
- Quality of cement
- Quantity of water

Water in concrete

Water in concrete fulfils a number a number of purposes:

1. It wets the surface of aggregate'
2. Facilitates the spreading of the cement over the fine aggregate,
3. Regulates the consistency and workability, and
4. Helps the setting of cement by forming crystalline masses of hydrated silicates

An excess of water, beyond that required for workability, decreases the strength of a concrete. The water should be clean (i.e. not muddy). Brackish well water is not usually objectionable. As Seawater retards setting, it should be avoided, especially if rapid hardening is aimed at.

Importance of quantity of water for mixing

The less the quantity of water used for Reinforced Cement Concrete or Plain Cement Concrete, the more closely will the particles knit together, making the concrete stronger and denser.

Any extra water beyond the minimum required for the above purpose tends to dilute the cement, which flows away from the interstices and the result is that the strength of the concrete is reduced.

If the strength is the principal consideration

Keep the amount of water used in mixing to a minimum consistent with workability.

The final strength attainable by a concrete is inversely proportional to the water-cement ratio.

Water cement ratio

Water cement ratio is the weight of water divided by the weight of cement in a concrete or mortar. The lower the water/cement ratio the higher will be the strength of the concrete.

One 50 kg cement bag may be taken equal to 35 litres

Abram's law

A law discovered by Duff Abram in USA and earlier (1892) in France by Ferret that the strength of a concrete or mortar depends only on the ratio of the weight of water to the weight of cement in the mix. The lowest water/cement ratio, which can be handled without vibration is about 0.45. The minimum amount of water necessary for the chemical action of the setting of cement is about 0.25 but more than this is needed in order to wet the sand and stone.

Therefore, even vibrated concrete or vacuum concrete must not be reduced to a water cement ratio below about 0.35

Curing of concrete

To develop high strength, it is necessary that cement concrete, whether plain or reinforced, must be kept moist for at least 14 day in India. This is called water curing or curing. All exposed surfaces of concrete to be cured should be well covered with old cement bags, hessian, or canvas,

which are kept moist. The surfaces may be kept moist by spraying water frequently. Horizontal surfaces may be kept covered with a layer of water by impounding it with small bunds of clay or mortar. Matting straw (100 to 150 millimetres thick), sand sawdust or earth (25 millimetres thick) may also be used to cover the watered forefaces of rooftop.

Curing or maturing is the process of keeping concrete or mortar damp for the first week or month of its life so that the cement is always provided with enough water to harden; this improves the final strength of concrete, particularly the surface, and should reduce surface cracking or dusting.

Curing of concrete is defined as "The maintenance of a satisfactory moisture content and temperature in concrete during its early stages so that derived properties may develop." The object of curing is to ensure that the hardening concrete hardens and reaches a certain degree of hydration so that desired properties develop. Four aspects to be catered for curing are:

- Evaporation of water from fresh concrete
- Effect of temperature
- Methods of curing
- Duration of curing

Loss of moisture from fresh concrete depends on the ambient conditions wind velocity, temperature, and humidity and exposed surface area, structural geometry; reinforcement layout and construction methods have a bearing on the curing procedure. Protection against moisture loss from fresh concrete is crucial for the development of strength, prevention of plastic shrinkage cracks as well as for durability. Time of commencement of curing and duration depends on the initial and final setting of the concrete.

Defects or failure of concrete

Defects or failures of concrete work are commonly traceable to one or more of the following causes

- The use of too much or too little water during mixing or water carelessly applied.
- Incomplete incorporation of the aggregate with the concrete
- Using concrete which has already begun to set
- The placing of concrete on dry foundations without thoroughly saturating their surfaces
- Repeated floating or trowelling of concrete surfaces
- Insufficient curing

Creep

Creep is gradual deformation of concrete under stress. This is sometimes useful to the builders and to the client since it tends to load the entire building uniformly. Hard-drawn steel at high stresses takes on a permanent extension also called creep.

Honeycombing

Local roughness of the face of a concrete wall caused by the concrete having segregated so badly that there is very little sand to fill the gaps between the stones at this point. Such concrete is weak and should be cut put and rebuilt if the wall is heavily loaded.

Laitance

Laitance is scum on cement concrete or over trowelled mortar. It is weaker than the rest of the concrete and should be cut away and covered with the pure cement wash before laying more concrete on it.

Shrinkage

The shrinkage of concrete during hardening is about 0.0004 of its length at one year (30 mm per 100 metres) and about half this value at two months. Cement mortar shrinks by a similar amount. Moisture movement during the drying of wetted concrete or the wetting of dried concrete is reversible, but the shrinkage is not reversible.

Dusting

Dusting is known as disintegration of concrete and producing dust because of lack of curing or excessive water in the mix, which may be caused by dirty sand.

Effects of various materials on concrete

Effect of frost

Frost is weather during which dew is deposited as ice.

The danger to construction caused by frost is that water expands by about 9% of its volume when it freezes. Therefore, concrete or mortar, which have not set and contain free water are disintegrated by it. Some wet bricks will chip and lose their arises in hard frost. If a concrete or mortar has begun to set it will generally continue to set without freezing because of the heat generated by the action of setting. New concrete or brickwork should be covered by at least a tarpaulin in frosty weather.

Substances & liquids

The following substances and liquids are injurious to concrete.

Some protective treatments are described but this information depends on quality of the concrete, the degree of concentration of the injurious substance, the condition of exposure, and the temperatures are also the factors that determine the severity of the attack. Protective recommendations are based on experience.

Acetic acid, Vinegar

Causes slow disintegration from which concrete can be protected by spar varnish, bituminous enamels, phenol formaldehyde varnish, paraffin wax, and hard rubber or for concentration up to 60%, acid resisting paints. Vinegar is a weak solution of acetic acid, which slowly disintegrates concrete and protection by paraffin wax is recommended.

Acids

All acids attack concrete, strong acids being particularly virulent, although weak acids can be stored in untreated concrete tanks if the concrete is impermeable. Greater immunity from attack by weak acids can be obtained by using high alumina cement or by impregnation with fluorosilicate solution. The later, and similar, treatments become ineffective if the skin is broken. The calcium salts contained in set cement are soluble in nearly all minerals or organic acid. For most corrosive acids, linings of asphalt, bricks, tiles, paints enamel, rubber, or acid resisting coatings are recommended as given hereinafter for specific acids. It must be noted that while most common acids e. g. nitric and sulphuric acid are destructive in high concentrations, hydrochloric acid is most injurious in lower concentration. Acid resisting cements are available, some of which are said to be resistant to all acids (except hydrochloric acid) in all strengths and at high temperatures.

For weak and medium acid solutions, paraffin wax or sodium silicate is used.

Hydrochloric acid	Particularly destructive, especially when hot. Diluted hydrochloric acid can penetrate thick coating of paraffin wax. Protective treatment as for sulphuric acid, including rubber linings.
Hydrofluoric acid	Lead linings are recommended and rubber is effective up to 150 degree Fahrenheit and for 50% solutions
Nitric acid	As for sulphuric acid, but rubber lining is not recommended except for low concentration.
Nitro-hydrochloric acid	Particularly destructive, especially when hot. Treatment same as for 'hydrochloric acid'
Phosphoric acid	Slowly disintegrates concrete due to formation of soluble acid phosphates. Requires protection as for acids generally, acid-resisting paints provide protection from all concentrations. If rubber is used it should be specially compounded.
Sulphuric acid	Disintegrating effect on concrete is guarded by glass, lead, vitrified brick or tile.
Sulphurous acid	Disintegrates concrete, rubber is effective for all concentrations.

Alcohol

Alcohol has practically no effect on concrete, but protection by acid-resisting paints is recommended.

Aluminium

Aluminium (and to a less extent zinc and lead can be seriously corroded when in contact with freshly place cement mortar or concrete. Corrosion is due to alkaline moisture that exudes from the concrete because of the setting process or changes in humidity. This moisture only attains on appreciable calcium hydroxide exceed 50% of the saturation value; crystalline calcium aluminates is precipitated, forming a protective coating which retards further corrosion. Inserting an impermeable layer of bituminous material between the concrete and the aluminium lining can

prevent corrosion. Glycerine-litharge mortars are recommended in place of cement and similar mortars when setting aluminium lining, and a strong material can be made by mixing 9 parts of crushed limestone (preferably by crusher) and 1 part of litharge with a solution of 35% of crude commercial glycerine and 65% of water.

Ammonia & ammonium compounds

Ammonia Hard rubber or special paints are recommended as protection for concrete against ammonia.

Ammonium chloride Ammonium chloride slowly attacks concrete. Protective coats are fluorosilicate, sodium silicate, linseed oil, bitumen, glass linings, vitrified brick or tile laid in litharge, rubber, and special paints.

Ammonium nitrate Ammonium nitrate disintegrates concrete, especially if the solution is in excess of ½ to 1%. Protective coats are fluorosilicate, sodium silicate, linseed oil, bitumen, glass linings, vitrified brick or tile laid in litharge, rubber, and special paints.

Ammonium sulphate Ammonium sulphate is probably the most aggressive of the sulphate salts and blue bricks laid on edge and set in pitch protect concrete floors of sulphate stores. Ammonium sulphate attacks concrete, necessitating protection as for sulphates i.e. Protective coats are fluorosilicate, sodium silicate, linseed oil, bitumen, glass linings, vitrified brick or tile laid in litharge, rubber and special paints

Anhydrites

High-alumina cement concrete resists attack

Anthracene

No effect on concrete, but in some cases treated with cement mortar to reduce seeping.

Beer

Fermentation tanks of concrete should be lined with enamel, glass, or stainless metal linings. Deleterious effects are more virulent when using ordinary cement, high-alumina cement concrete being immune.

Benzene, petrol, paraffin, naphthalene, turpentine

No deleterious effect on concrete. Loss due to seeping may be considerable as petrol can find its way through pores that are impermeable to water. Applications of fluorosilicate, spar varnish, sodium silicate, or phenol formaldehyde varnish are surface treatments. Impregnation of the concrete with water reduces the permeation of petrol, and a water barrier within the thickness of the walls has proved effective. Petrol vapours can also pass through concrete; rich mixture of concrete or a high water cement ratio apparently slightly increases the rate of penetration, glycerine, glue, or asphalt does not provide protection.

Benzol, cumol, tolol, xylol

No injurious effect on concrete, but slight seeping may occur. Skimming coats of water proofed cement; with two coats of cement-grout will be successful. Asphalt should not be used, as it is

soluble in benzol.

Calcium compounds

Calcium chloride Calcium chloride has no injurious effect on concrete and is sometime used to accelerate setting and for curing. It may have corrosive effect on reinforcement.

Calcium nitrate Calcium nitrate has no effect on concrete.

Calcium & magnesium sulphate, Calcium sulphate (gypsum) is often found in clays, the ground water from which may contain solutions of sufficient strength to attack cement concrete, although high alumina cement concrete may be immune

Carbolic acid (a white, crystalline, water-soluble, poisonous substance, C_6H_5OH.)

Carbolic acid attacks poor concrete, although cases have been recorded where untreated 1: 1½: 3 concrete 150 millimetres thick with steel-float finish is successful.

Carbonium, creosote, cresol, phenol

Disintegrates concrete very slowly, no treatment is necessary.

Carbonic acid (H_2CO_3, formed when carbon dioxide dissolves in water

Carbonic acid when dry has no effect on concrete, but causes slow disintegration, when in solution. Treatment is asphalt, bituminous paint, coal-tar paint, fluorosilicate spar varnish, or phenol formaldehyde resin.

Caustic soda (Sodium hydroxide, a white deliquescent solid, NaOH

Caustic alkalis have little effect on cement concrete although they may attack high-alumina cement concrete. Alkali-resistant paints will provide protection of any concentration.

Chlorides

Chlorides have little or no effect on concrete except in high concentrations, while others cause slow disintegration and require protection as for sulphates.

Chlorine solutions

Chlorine Solutions have no effect on cement concrete.

Cider

Paraffin wax treatment is successful.

Citric acid (A white powder, $C_6H_8O_7H_2O$)

Acid resisting paints provide protection against all concentrations.

Cobalt sulphate, sulphates, sulphides

Sulphate/sulphides vigorously attack concrete. Protective coats are fluorosilicate, sodium silicate, linseed oil, bitumen, glass linings, vitrified brick or tile laid in litharge, rubber and special paints

Copper compounds

Copper chloride attacks concrete slightly and requires treatment as for sulphates. For copper nitrate, acid-resisting paints afford protection. For copper sulphate refer protection prescribed for 'sulphates'

Cotton seed oil

No treatment is necessary as attack is very slight.

Fish oil, foot oil, lard

Fish oil attacks cement concrete only slowly, and treatment with fluorosilicate, sodium silicate, or linseed oil is recommended.

Formaldehydes

Protection by paints is recommended.

Formic acid (a colourless, irritating, fuming liquid, CH_2O_2

Acid resisting paint provides protection against solution up to 60%. (Refer 'acid')

Fumes

Fumes such as acid vapours that occur in dye works, pickling plants, bleaching works and galvanising works, attack concrete. Lacquers can provide protection. Protection is also required for concrete exposed to smoke the sulphur in which leads to the formation of sulphuric acid.

Gallic acid (White or yellowish solid, $C_7H_6O_5$ obtained from nutgalls, used esp. in tanning & dyes

Mostly contained in ink, storage vats require protection by one of the coatings given for acids or by ink resisting linings.

Glucose, corn syrup

Slowly attacks concrete. Requires protection as for 'sulphates'.

Glycerine (a colourless liquid, $C_3H_8O_3$

Protection required as for 'sulphates'.

Iron & iron compounds

Iron or steel built into or attached to exposed concrete may lead to discolouration of the concrete due to rust. For the compounds of iron, the remarks for magnesium chloride apply to ferric chloride, those for copper nitrate apply to ferric nitrate, and those for sulphates apply to ferric sulphate.

Lactic acid (a syrupy liquid, $C_3H_6O_3$)

Derived from milk and occurs in whey and sour milk. Cement concrete is attacked and can be treated as carbonic acid in water or coating of linseed oil, paraffin wax, or paints. High-alumina cement concrete is attacked to less degree. Sodium silicate provides only temporary protection against deterioration of concrete floor subject to milk spilling, and tiles laid in asphalt are recommended for permanent protection. Channels are often lined with vitreous material.

Lead & lead compounds

For the effect on lead of contact with wet concrete, refer 'Aluminium'. Lead pipes passing through concrete may be protected by a coaling pitch or tar or by embedding the pipes in clay. For lead nitrate refer 'copper nitrate' and for lead sulphate refer 'sulphates'.

Lime

Refer 'calcium compounds'. Gas works lime attacks cement, high-alumina cement concrete being more resistant. Cement concrete treated with special paints is also effective. Pile driven

through gas works lime should be protected by a coating of tar.

Magnesium chloride, mercuric chloride

Magnesium chloride and mercuric chlorides slowly attacks concrete - protection as for sulphates. No protection is required if in weak solutions as in ground waters.

Nitrates

No effect

Nut oil, olive oil, poppy seed oil, rape seed oil

Almond oil, coconut oil, peanut oil, and walnut oil slowly disintegrate, which can be protected by fluorosilicate, sodium silicate, or linseed oil.

Oils

Vegetable oils attack concrete and make it spongy. Mineral oils have no destructive effect, and thus light fuel oils such as petrol, paraffin and benzol, can be stored in concrete without injurious effect, but applications of spar varnish, linseed oil, or sodium silicate are recommended to provide protection against seeping oils.

Phosphates

No serious attack no remedy is required.

Pyrites

Slow attack. Remedy as prescribed for sulphates.

Rubber

Used as protection for concrete containers holding corrosive liquids. Hard rubber is more resistant to chemical attack than soft rubber. Rubber is not a protection against powerful oxidising agents such as nitric and chromic acid, ozone, etc.

Salt (common)

Common salt (sodium chloride) is not injurious to concrete when dry. Sodium silicate is treatment for plain concrete. High alumina concrete offers immunity than ordinary cement concrete.

Sewage

The acid content is generally low. High-alumina cement concrete is more resistant than ordinary cement concrete.

Sodium compounds

Sodium compounds have no effect on concrete. Use Sodium silicate as protective coating and pore filler.

Soya bean oil

Harmless

Sugar

Sugar juices injure ordinary cement concrete, as such high-alumina cement concrete is recommended

Sulphates, sulphides, sulphide liquor

All the sulphates, sulphides vigorously attack concrete. Protective coats are fluorosilicate, sodium silicate, linseed oil, bitumen, glass linings, vitrified brick or tile laid in litharge, rubber, and special paints.

Tannic acid

Derived from tea, has slow disintegration effect on concrete, high alumina concrete is immune.

Tanning liquor

When tanning liquor is non-acid type, no protection is required. If acid type, bituminous paint is protection

Wine

The treatment of the interior of wine vats with a solution of fluorosilicate or with tartaric acid has been successful and had no ill effect on the contents. Vats treated with potassium silicate solution are reported to contaminate wine.

Zinc

For the effect of zinc in contact with wet concrete, refer 'Aluminium'. For Zinc-sulphate and chloride, refer 'sulphates'.

Moisture movement

It is the property, which causes a material to increase in length when its moisture contents increase. Most of these materials also shrink when their moisture contents falls (all solids, cement products, timbers, wood products, bricks). The reversible moisture movement of concrete or concrete bricks varies from 0.01 to 0.055%, the first and non-reversible drying shrinkage being from 0.02 to 0.08%.

The moisture movement of clay building bricks is usually below 0.01% but that of sand-lime bricks may vary from 0.001 to 0.05%.

Clinker concrete may have up to 0.02% and for this reason clinker blocks must be kept dry before they are built in, otherwise severe cracking of the plaster over the blocks must be expected when the blocks dry out as the house is warmed by its occupants.

Redwood along the grains has 0.17% but across the grain, the much larger value of 0.7%. This is the expansion, which causes panelled softwood doors to be too tight in winter if they fit the frame well in summer.

Soils, particularly clays, expand with increasing moisture content. Clays shrink with decreasing moisture content until the shrinkage limit is reached.

Foundation

Foundation is the part of the structure, which is in direct contact with and transmitting load to the ground.

Excavation & earthwork

For buildings, excavation is digging out of earth to make room for engineering improvements.

Soils

Soils is the part of the earth's surface consisting of humus and disintegrated rock

Classification of soils

Alluvial	Soil made of sand, earth, etc left by rivers or floods.
Clay	A common earth, compact and brittle when dry, but plastic when wet. Used in the manufacture of bricks.
Loam	Loam is a roughly equal mixture of sand, clay, and silt. (A mixture of sand and clay)
Silt	Silt is granular material finer than sand but coarser than clay, that is from 0.002 to 0.06 millimetre. It feels gritty between the fingers but the grains are difficult to see. It can be distinguished from clay by the shaking test or by rolling it into a thread. A thread of silt crumbles on drying a clay thread does not.
Black cotton soil	It derives its name from its black colour and from the fact that cotton grows on it very well. The black cotton soil has high swelling and shrinkage properties. The soil is hard so long it is dry but looses its stability almost completely when wet. Further, on drying, the soil shrinks and cracks very badly. The construction in such soil areas has always presented serious problems because of the extremely low bearing capacity when it is wet and also on account of high swelling characteristics during process of wetting
Kaolin	China clay. Fine white clay used in making porcelain and in medicine. It retains its white colour when fired. The material was first obtained from a hill called Kaoling.

Size of soil particles

Soil particles are described (after mechanical analysis of a soil sample) as sand silt or clay based on the following size limits in mm. Clay is defined by their consistency limits.

Description	Size in millimetre
Coarse sand	2.0 to 0.6
Medium sand	0.6 to 0.2
Fine sand	0.2 to 0.06 [0.06 (200 mesh sieve)] smallest practicable size for sieving
Coarse silt	0.06 to 0.02
Medium sand	0.02 to 0.006
Fine sand	0.006 to 0.002

Description	Size in millimetre
Clay	Under 0.002

Safe bearing pressure/capacity of soils

Wet clay	11 Tonne per square meter	or 1022 kilogram per square feet
Firm clay	22 Tonne per square meter	or 2045 kilogram per square feet
Wet Sand	22 Tonne per square meter	or 2045 kilogram per square feet
Fine and dry Sand	33 Tonne per square meter	or 3066 kilogram per square feet
Hard and dry Sand	44 Tonne per square meter	or 4088 kilogram per square feet
Coarse sand	44 Tonne per square meter	or 4088 kilogram per square feet
Sand and clay mixed in layers	22 Tonne per square meter	or 2045 kilogram per square feet
Gravel	66 Tonne per square meter	or 6132 kilogram per square feet
Soft rock	88 Tonne per square meter	or 8175 kilogram per square feet
Medium rock	164 Tonne per square meter	or 15236 kilogram per square feet
Hard rock	438 Tonne per square meter	or 40691 kilogram per square feet

Types of foundations

The most common types of foundation systems are classified as shallow and deep. Shallow foundation systems are several feet below the bottom of the building; examples are spread footings and mats. Deep foundations extend several dozen feet below the building; examples are piles and caissons. The foundation chosen for any particular building depends on the strength of the rock or soil, magnitude of structural loads, and depth of groundwater level.

The most economical foundation is the reinforced-concrete spread footing, which is used for buildings in areas where the subsurface conditions present no unusual difficulties. The foundation consists of concrete slabs located under each structural column and a continuous slab under load-bearing walls.

Mat foundations are typically used when the building loads are so extensive and the soil so weak that individual footings would cover more than half the building area. A mat is a flat concrete slab, heavily reinforced with steel, which carries the downward loads of the individual columns or walls. The mat load per unit area that is transmitted to the underlying soil is small in magnitude and is distributed over the entire area. For large mats supporting heavy buildings, the loads are distributed more evenly by using supplementary foundations and cross walls, which stiffen the mat.

Piles are used primarily in areas where near-surface soil conditions are poor. They are made of timber, concrete, or steel and are located in clusters. The piles are driven down to strong soil or rock at a predetermined depth, and each cluster is then covered by a cap of reinforced concrete. A pile may support its load either at the lower end or by skin friction along its entire length. The number of piles in each cluster is determined by the structural load and the average load-carrying capacity of each pile in the cluster. A timber pile is simply the trunk of a tree stripped of its branches and is thus limited in height. A concrete pile, on the other hand, may be of any

reasonable length and may extend below groundwater level as well. For extremely heavy or tall buildings, steel piles, known as H-piles because of their shape, are used. H-piles are driven through to bedrock, often as far as 30 m (100 ft) below the surface. H-piles can be driven to great depths more easily than piles made of wood or concrete; although they are more expensive, the cost is usually justified for large buildings, which represent a substantial financial investment.

Caisson foundations are used when soil of adequate bearing strength is found below surface layers of weak materials such as fill or peat. A caisson foundation consists of concrete columns constructed in cylindrical shafts excavated under the proposed structural column locations. The caisson foundations carry the building loads at their lower ends, which are often bell-shaped.

Groundwater level

Foundation construction is complicated by groundwater flowing above the bottom of the proposed foundation level. In such cases the sides of the excavation may be undermined and cave in. Lowering the groundwater level by pumping the water out of the excavation usually requires the installation of braced sheathing to shore up, or retain, the sides of the excavation to prevent any cave-ins. When the amount of water within the excavation is excessive, ordinary pumping methods, which bring to the surface loose soil mixed with the water, can undermine the foundations of buildings on adjoining property. To prevent damage caused by soil movement, well-point dewatering is often used. Well-points are small pipes with a perforated screen at one end. They are driven or jetted into the ground so that the screen, which prevents soil from flowing in with the water, is below groundwater level. These pipes are linked to a common manifold (pipe) that is connected to a water pump. In this way, the groundwater is removed from below the excavation without damaging nearby property. Dewatering may also make it unnecessary to sheathe the sides of the excavation, providing the soil will not slide into the excavation because of its composition or because of vibrations from nearby traffic or machinery.

Pile foundation

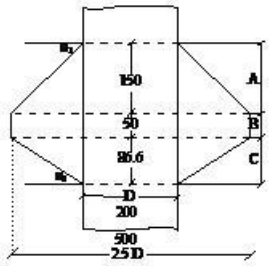
Volume of one UR portion of a pile

$\theta_1 = 45^{\circ}$; $\theta_2 = 30^{\circ}$

$150 \times \tan \theta_1$ = 150 millimetre

$150 \times \tan \theta_2$ = 86.6 millimetre

Total volume = A + B + C



Volume of portion 'A'

$$= \frac{1}{3} \times \pi \times h \times (R_1^2 + R_2^2 + R_1 \times R_2)$$

$$= \frac{1}{3} \times 3.14159 \times 0.15 \times (0.10^2 + 0.25^2 + 0.10 \times 0.25) = 0.0153\ cum$$

Volume of portion 'B'

$$= \frac{1}{4} \times \pi \times D^2 \times h = 0.25 \times 3.14159 \times 0.50^2 \times 0.05 = 0.00981\ cum$$

Volume of portion 'C'

$$= \frac{1}{3} \times \pi \times h \times (R_1^2 + R_2^2 + R_1 \times R_2)$$

$$\frac{1}{3} \times 3.14159 \times 0.866 \times (0.10^2 + 0.25^2 + 0.10 \times 0.25) = 0.00884 cum$$

Total volume of portion 'A', B' & 'C'

=0.0153 + 0.00981 + 0.00884 =0.03391 Cu M

Deduct volume of pile portion

$$= \frac{1}{4} \times \pi \times D^2 \times h$$

$$= 0.25 \times 3.14159 \times 0.20^2 \times (0.15 + 0.05 + 0.0866) = 0.009003\ cum$$

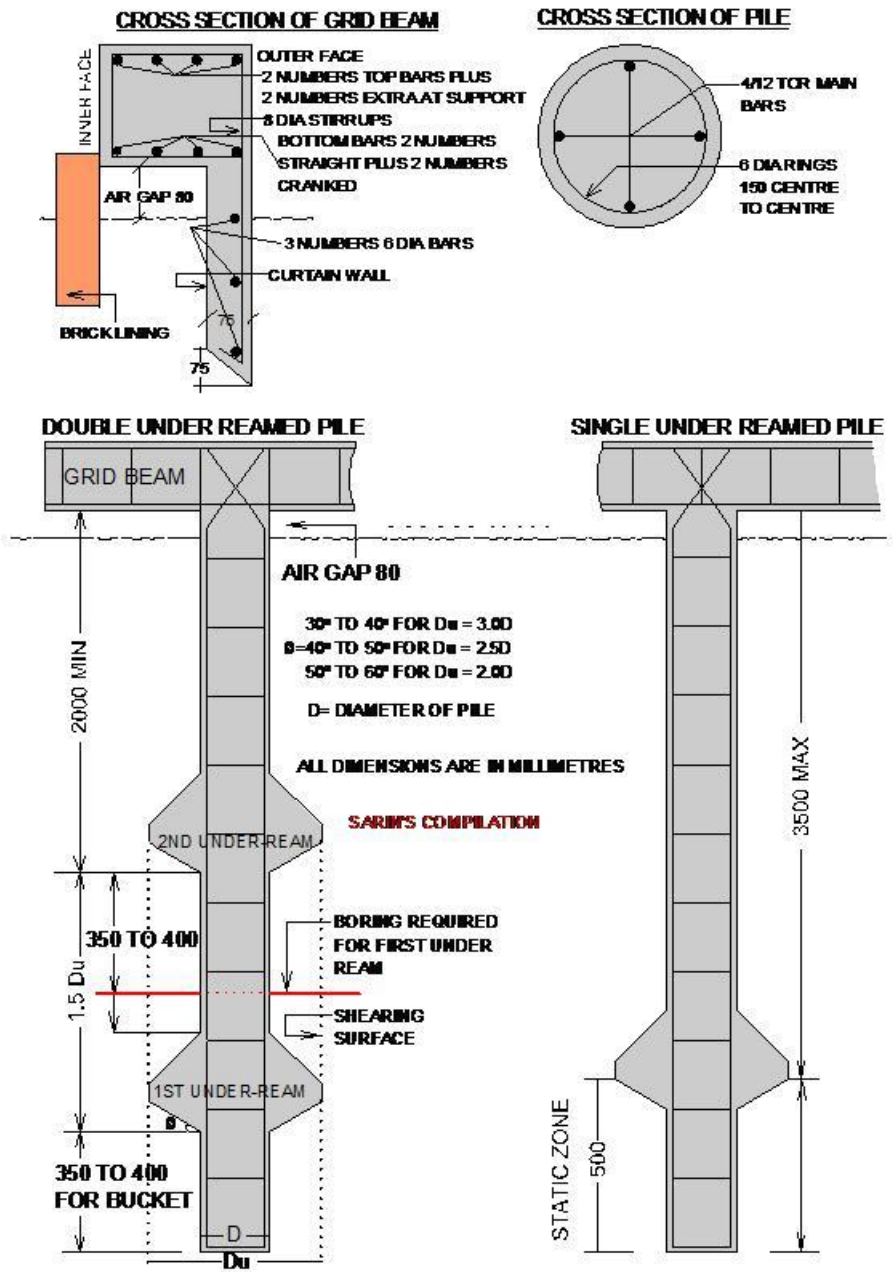
Net volume of one under reamed portion of pile

= [0.03391 – 0.009003] = 0.024907 Cu m Say 0.0249 Cu m

Volume of 1 under reamed portion of pile of different dia

Diameter (mm)	250	300	375	400	450	500
Quantity (cum)	0.049	0.084	0.165	0.200	0.284	0.390

Sections of grid beam & pile stem

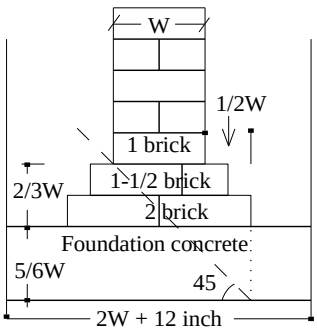


Setting out foundations for excavation

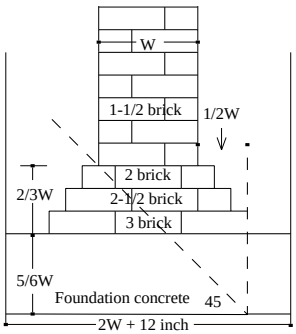
1. Study carefully all drawings, specifications as provided by your architect.
2. Do not attempt to set out the building until you have a foundation plan. The plan should show the widths and lengths of foundation trenches and the centre lines of walls.
3. Set out the centre lines on the ground after first having verified that the site and orientation are correct.
4. Use steel tape for all measurements in connection with setting out.
5. Drive in wooden pegs clear of the building on extensions of the centre lines of walls, with the top of the peg a little above plinth level.
6. Mark extensions of centre lines exactly on these pegs and drive in wire nails to mark these exact alignments. Leave the head of these nails one centimetre above the top of the peg.
7. At this stage, check all dimensions, i.e. lengths of all walls, and right angles. Do not use mason's square for this purpose. Use a tape and measure off the lengths in the ratio of 3: 4 along the two walls forming the right angle. The third side of the triangle thus formed should measure five units.
8. Build up masonry pillars around these pegs, finished with cement plaster on top exactly to plinth level.

Details of foundations

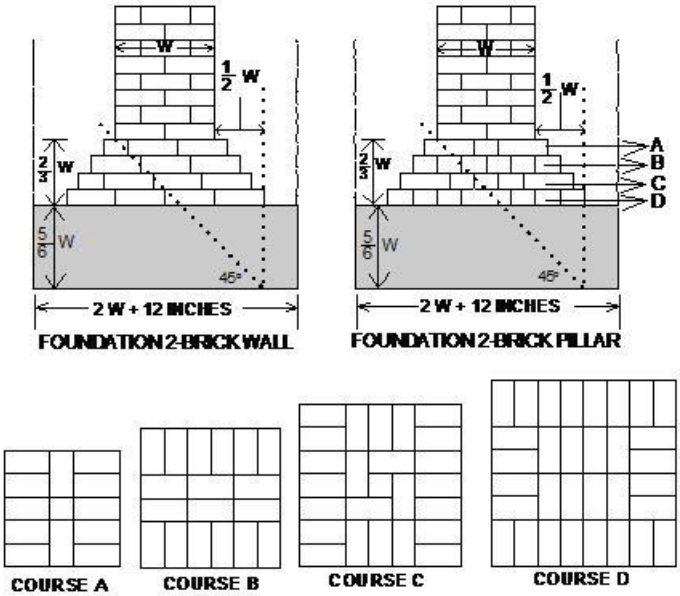
Foundation 1-brick thick wall



Foundation 1½-brick thick wall



Foundation 2-brick wall & pillar



Excavation for foundations

Foundation is the most important part of a building. An expert should always do design of foundation. Design of foundation depends upon the nature of soil, its bearing capacity, type of construction, numbers of storey, etc. In real terms, it is not possible for every man to get the soil tested for its bearing capacity. It requires expertise and money. Furthermore the facility of soil testing is not available everywhere.

Workmanship

Av output of a excavator labourer

The average digging of a labour (mazdoor) or a person is 0.40 cum per hour. The output in first four hours may be as under for a maximum for a trough of 3.5 metre and mean lift of 1.5 meter:

Sequence of hour	Output		Percentage
First hour	= 0.85 Cubic metre	or 30 cu ft	= 38%
Second hour	= 0.70 Cubic metre	or 25 cu ft	= 31%
Third hour	= 0.40 Cubic metre	or 14 cu ft	= 18%
Fourth hour	= 0.30 Cubic metre	or 11 cu ft	= 13%
Total	= 2.25 Cubic metre	or 80 cu ft	= 100%

Excavation in trenches

1. Remove filled material and dig the foundation trench up to the natural soil. Do not lay foundation until hard soil / moorum / rocks is met with
2. Depth of the foundation trench should not be less than 3 feet (90 cm).
3. Width of the foundation trench should be equal to twice the thickness of the wall (measured above the Damp Proof Course) plus 1 foot (30.5 centimetres). For inner load bearing walls increase the width of foundation and footings
4. In case of loose or black cotton soil or for multi storied buildings always consult engineer/expert. Never go with mason's advice.
5. If the excavation has been done in excess of that shown in drawings by mistake, the extra depth should not be filled with earth but made good by concrete of a mix to be provided in the e foundation.
6. It is advisable that you should personally check the bottom of foundation trench and get the defective soft spots, if any, dug out. Fill these soft spots with concrete of same mix. Do not fill and compact it with earth.
7. Ensure that bottom of foundation trench is well compacted before the concrete is laid.
8. Provide anti termite treatment to bottom and sides of trenches.
9. After anti termite treatment do not dug further or add earth in the trench.

Returning filling in trenches

1. As soon as the work in foundation is complete, get the space around the foundation masonry in trench cleaned of all debris and brickbats, etc.
2. Filling up of earth must be done in layers as the masonry-work in plinth proceeds.
3. Fill the trenches around the masonry with earth in layers not exceeding 8 inches (20 cm) thick. Each layer shall be watered, rammed, and compacted before laying the succeeding layer.
4. Use iron hand-rammers (durmoot) of 7 to 10 kilogram weight. Where use of hand rammer is not feasible, use butt-end of crow bar for ramming
5. Pay attention to ramming at junction of floors with walls and columns.
6. The top surfaces of the compacted earth shall be neatly dressed level or to a slope or grade as required.
7. The earth used for filling should be free from deleterious materials.
8. Provide anti-termite treatment to back filled earth.

Pre-construction anti-termite measures in buildings

Process of application of anti-termite treatment to wall foundation and other locations is shown in the diagram shown herein below

Legends

B Back fill in immediate contact with foundation wall

F Soil below apron

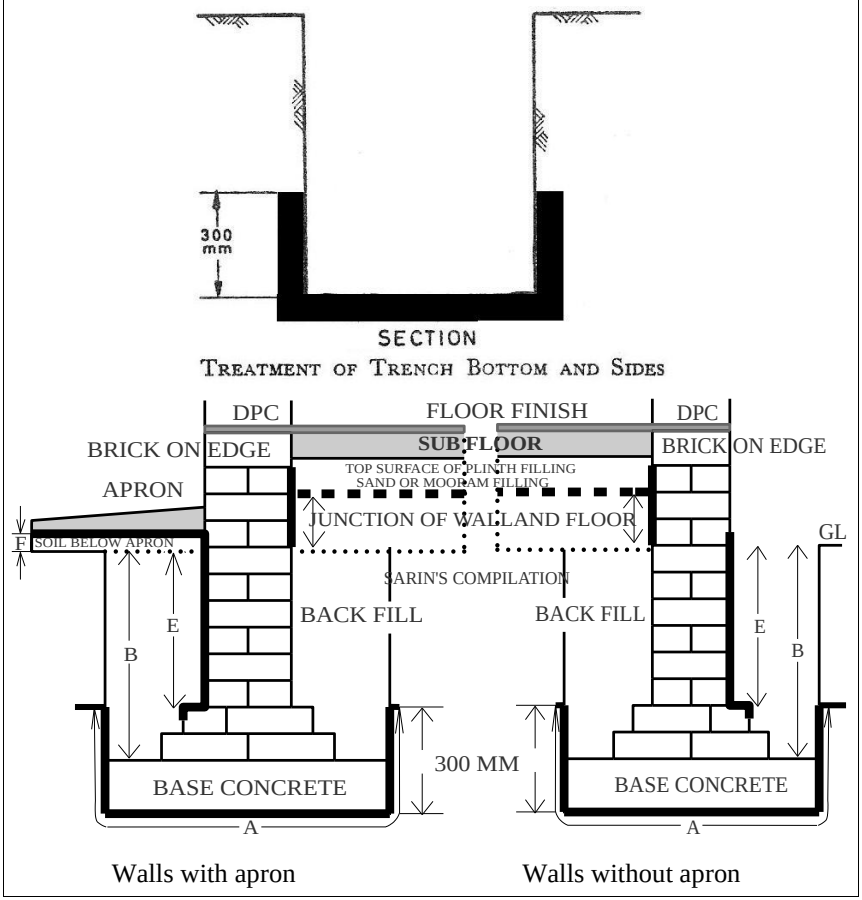
E External perimeter of building

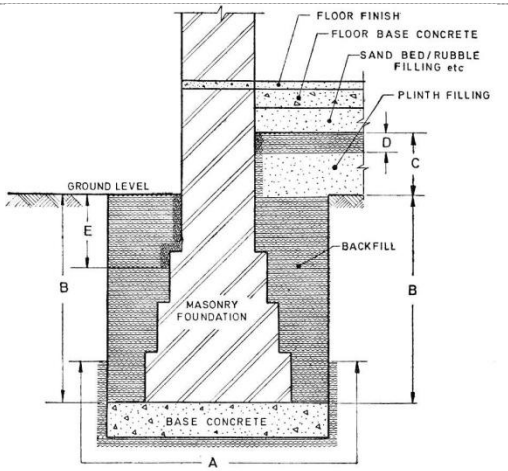
| Double treatment

Single treatment

ATT for load bearing walled structure along external perimeter

Treatment of foundation trench bottom & sides

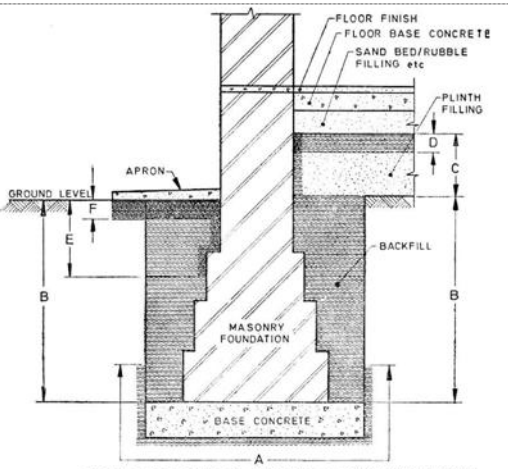




Treatment for Load Bearing Walled Structure Without Apron

Treatment Double Treatment

Stages of Treatment
A — Bottom and sides of trenches
B — Backfill in immediate contact with foundation walls
C — Junction of wall and floor
D — Top surface of plinth filling
E — External perimeter of building

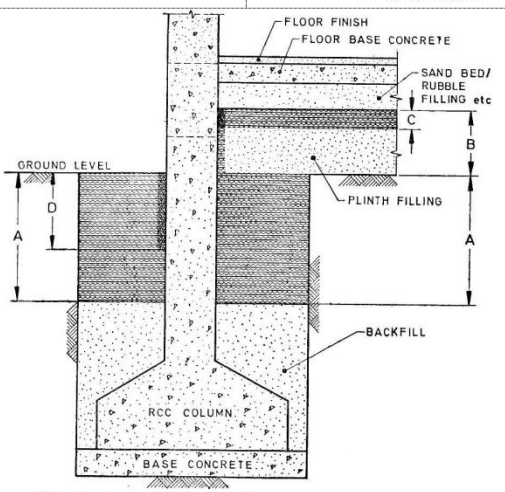


Treatment for Load Bearing Walled Structure With Apron Along External Perimeter

TREATMENT FOR LOAD BEARING WALLED STRUCTURE

Treatment Double Treatment

Stages of Treatment
A — Bottom and sides of trenches
B — Backfill in immediate contact with foundation walls
C — Junction of wall and floor
D — Top surface of plinth filling
E — External perimeter of building
F — Soil below apron



TREATMENT FOR RCC FRAMED STRUCTURE WITH COLUMNS AND PLINTH BEAMS

Treatment Double Treatment

Stages of Treatment
A — Backfill in immediate contact with foundation structure
B — Junction of wall and floor
C — Top surface of plinth filling
D — External perimeter of building

Soil treatment to partially erected buildings

Soil treatment can be applied to a building, which has progressed above plinth level provided the concrete bed for taking the floor finish has not been laid.

Any one of the following chemicals conforming to relevant IS in water emulsion may be used for the soil treatment in order to protect a building from termite attack:

Chemical	**Concentration**	**Relevant IS**
Aldrin Emulsifiable concentrates	0.5 % by weight	IS: 1307
Heptachlor emulsifiable concentrates	0.5 % by weight	IS: 6439
Chlordane emulsifiable concentrates	1.0 % by weight	IS: 2682
Di-aldrin	0.5 % by weight	—
Chloropyriphos	1.0 % by weight	—

The soil in contact with the external perimeter of the building shall be treated at the rate of 5 litres per running meter per 30 cm depth of foundation. To facilitate the treatment a trench shall be excavated the width of a shovel exposing the foundation wall surface up to a depth of 45 cm (18 inch) and rod holes 15 cm (6 inch) apart shall be extended from the bottom of the trench to the top of the footing of the foundation or to a depth of 45 cm. Half the quantity of chemical shall be poured into these holes and the balance mixed with the earth as the trench is filled.

The entire surface of the earth filling within the plinth walls shall be treated with emulsion at the rate of 5 litres per square metre. The surface of the earth may be lightly rodded, if necessary, to enable the emulsion to seep in. also a trench about 23 cm (9 inch) deep should be excavated also the internal perimeter wall and on both sides of all internal walls to enable the emulsion to soak well along the wall surface. This effect can be achieved by rodding at close intervals along wall perimeter up to a depth of 23 cm. All spraying shall be carried out with pressure pump to facilitate proper penetration of chemical into the earth.

Foundation concrete

1. Thickness of foundation concrete should not be less than 20 cm (8 inch) or five sixth of the thickness of the wall.
2. Lay the foundation concrete on well-compacted base.
3. Do not allow the labour to throw the concrete in the foundation trench from a height of more than 1-metre. Employ one extra labour to receive the concrete by standing inside the trench and pour it where required by the concreter.
4. Do not let the excavated earth fall in the foundation trench during and after the concrete is laid.
5. Lay concrete in even layers not more than 15 cm (6 inch) thick. A chalk line can easily be snapped along the side of the trench indicating the thickness of each layer so that labours doing the concreting have a marking to work.
6. Ensure that water content is not excessive. No water should be added once the mixing is completed. Do not use any water more than water cement ratio.

Damp proof course

Integral waterproofing compound only help in making good concrete better and disrupts the capillary network within the concrete mass. It also reduces the possibility of shrinkage cracks. Hence, observance of good construction practice is of utmost importance for achieving the overall goal. So maintain: —

1. Proper mix design
2. Use of good water proofing compound preferably ISI marked
3. Selection of good aggregate, sand and cement
4. Proper water cement ratio in the range of 0.45
5. Proper mixing, placing, and curing
    - Use only ISI marked Water Proofing Compounds.
    - Provide 1 inch (25 mm) thick Plain Cement Concrete (1:2:4) with ½ inch (12 mm) graded stone aggregate and coarse sand
    - First, mix the powder with cement by hand with rubbing and sieve this dry mix. Now mix the concrete in usual manner.
    - Maintain proper water cement ratio.
    - Do not provide damp proof course in door or other openings.

Stone masonry

Ashlar stone

Dressed stone used for the outside facing of a wall. A squared building stone cut more or less true on all faces adjacent to those of other stones so as to permit very thin mortar joints.

Ashlars, soft stones

Length shall not be more than 3 times height.

Ashlar, hard stone

Not more than four or five times height.

For masonry of considerable height, facing of ASHLAR with interior of rubble is objectionable as very liable to unequal settlement. It is better to have masonry of one character throughout, whether it is Rubble or Ashlar. In large masses of masonry exposed to great pressure of water, as dams, un-coursed rubble is preferable to ashlars.

Rubble

Rough fragments of broken stone, formed by geological processes, in quarrying, etc., and sometimes used in masonry

Random

Lacking uniformity of dimensions i.e. without apparent method or system; (of ashlar) laid without regularity

Bond stones

In stone masonry a stone running through the thickness of a wall at right angles to its face, serving to bind it together along its thickness.

Provide bond stones 4 to 5 feet (120 to 150 cm) apart in each course. Width of bond stone should be equal to 1½×height, surface of ends = ⅛ to ¼ total area of face wall.

Lap of stones

Lap of stone should remain 1 to 1½ times height of course.

Dressing – stone masonry

Ashlars

Ashlar is formed of squared stone in courses over 300 mm (1 foot) deep; beds and joints truly dressed and joints not exceeding 12 mm (½ inch) thick.

Ashlar chamfered

Edges of round exposed face of each stone to be bevelled off to 45º for 25 mm (1 inch) or more depth. Rock face or "bushing" shall not to project more than 75 mm (3 inches) from bed joints.

Ashlar fine

Every stone is to be fine-tooled on all beds joints and faces, full and true.

Ashlar rock faced

Stone faces exposed to view may or may not have chisel drafts. Between the bed joints, the exposed faces of stones to be left rough, but no rock face or "bushing" to project more than 75 mm (3 inches) from bed-joints.

Ashlar rough-tooled or bastard

Stone faces exposed to view to have fine-dressed chisel draft 25 mm (1 inch) wide, all round the edges and to be rough-tooled between the drafts.

Ashlars rustic

In which the face-work is left roughly scrabbled.

Block-in-course

Stones are roughly squared, the beds true, but the vertical joints scrabbled. Usually Block-in-course is in courses less than 300 mm (1 foot) deep.

Rubble masonry

Uncut stone, used for rough work, foundation, backing, etc

Random rubble (second sort)

Face and joints to be only hammer-dressed and not chisel –dressed.

Random rubble (first sort)

Face stones are to be carefully fitted to form neat and close joints. If necessary, the edges will be dressed with chisel. In other words, stones of regular shape in which no attempt is made to work in courses.

Rubble

Rubble stones are nearly as they come from the quarry, being merely dressed with the scrabbling hammer.

Un-coursed stones to be used as received from quarry, after merely knocking off weak corners and edges with mason's hammer. In other words, stones of irregular shape sometimes worked up to a level at intervals of from 450 to 650 mm (18 to 26 inches).

Rubble coursed

For rubble coursed face stones to be squared on all joints and beds, beds to be hammer- or chisel dressed true and square, for at least 75 mm (3 inches) from face. Face to be hammer-dressed. Projection of rock-faced surface shall not to exceed 40 Mm beyond bed-joint. In other words, generally it is of stones with a natural bed, laid in courses.

Rubble sneaked

Rubble sneaked is called when parts of each course are made up of two or three of thickness.

Cement constant

Description of item of work	Ratio	Unit	Cement
Stone masonry: walling of random or polygonal rubble un-coursed or brought up to course well bonded, bedded, and solidly hearted in gauged mortar.	1:1:6	Cum	73.80 kg
	1:1:8		56.89 kg
	1:2:9		49.71 kg

Brick masonry

Terminology

Bat (brick-bat)	Any portion or part of a brick, cut or broken across its length greater than one quarter, Usually known according to its fraction from the whole size, as for example ½ bats, ¾ bats.
Bay	The space between two piers, columns, or projections A small recess opening off a larger room
Bond	A systematic arrangement of unit of brick or stone courses
Bull's eye	A circular or oval opening in a wall
Closure	A portion of a brick either manufactured or cut from whole brick to the necessary size and shapes to maintain the bond e.g. King closure, queen closure, and bevelled closure.

Corbel	Bricks built out from the face of wall to form a bearing surface. A triangular bracket of brick or stone (usually of slight extent)
Cornice	Horizontal moulded projection or A moulding at the corner between the ceiling and the top of a wall
Course	Horizontal layer of bricks in a wall
Efflorescence	Deposits of salts forming on brickwork surface exposed to atmosphere.
Face brick	Brick of a better quality, such as, is used on walls prominently exposed
Flashing	Flexible material, usually metal, used for a watertight joint
Footings	Brick lay with its long axis at right angles to the face of the wall.
Header	A brick or stone placed with its end toward the face of wall
Header bond	Brick is laid in a wall, usually connecting two rows of a double the wall. The smallest end of the brick is horizontal, aligned with the surface of the wall and exposed to the weather.
Parapet	That portion of the wall carried up above the level of the roof. A low protective wall along the edge of a bridge, roof, balcony, etc.
Perpend	1. The vertical joint between bricks appearing on the face of the wall 2. An alignment of cross-joint, which can be checked with a plumb line 3. A header brick extending through the wall so that one end appears on each side of it
Pilaster	A right-angled column or projection from a pier or wall; a square pillar made generally to support a concentrated load. A rectangular column that usually projects about a third of its width from the wall to which it is attached
Quoin	Solid exterior angle of a building; especially one formed by a cornerstone The keystone of an arch
Quoin bond	Or "coin" - are groups of brick that project slightly from the face of a wall at the corner of a building. The pattern often alternates with several courses projecting bricks, and several courses that are aligned with the wall. The pattern of projecting quoins often alternates with the brickwork on the other side of the corner.
Reveal	The part of the jamb between the frame and the arris i.e. The visible part of each side of a recess or opening of a wall
Racking	In approaching a corner where two walls meet, "racking" is the making of each course shorter than the course below it, in order that the worker on the walls may tie in their courses in the easiest manner.
Rowlock	'Brick on edge': A complete course of brick placed on its side, with the shortest end of the brick exposed and vertical. Commonly used on the top course as a coping for garden walls.

Sleeper wall	Low walls erected at intervals between the main walls to provide intermediate supports to the lowest floors.
Spall	Bat or broken brick; stone chips.
Squint brick	Bricks used for forming accurate or obtuse corners in brick masonry.
Storey rod	A rod on which is marked the various courses, and other necessary heights
Stretcher	A brick or stone lying lengthwise in a course i.e. long axis parallel with the face of the wall
Stretcher bond	Brick (or other masonry block) placed horizontally in the wall with the long, narrow side of the brick exposed. Commonly used for English bond and Flemish bond pattern, alternating with header bricks.
Striking	The releasing or lowering of centering of arches or lintels
String course	A horizontal plain or moulded band projecting slightly from the face of the wall
Substructure	That part of any structure that is below ground, in particular the foundations and piers of bridge.
Superstructure	The visible part of a structure; that part above the sub structure
Sailor	Brick placed vertically on its end with the largest, broad face exposed.
Shiner	Brick laid on edge like a sailor, but the broad face is set horizontally.
Soldier	Often a complete course of brick placed on end vertically, with the narrow side exposed in the face of the wall. A "standing soldier" is the most common way of setting the soldier brick on end that is flush with the wall. A "walking soldier" is a soldier course laid so the bottom edge of the brick is sticking out to about an inch. Usually alternating every other brick with a standing soldier, but other variations has been seen.
Threshold	The bottom of an external door opening is provided with one or more steps, which form a threshold.
Underpinning	The process of supporting of existing structure for renewing or repairing the lower walls or foundations

Bricks

Brick is block of clay or other ceramic used for construction and decorative facing. Bricks may be dried in the sun but are more usually baked in a kiln. They cost relatively little, resist dampness and heat, and can last longer than stone. The colour varies according to the clay used and in proportions according to architectural tradition. Some bricks are made of special fireclays for use in fireplaces or ovens. Bricks may be arranged in various patterns, called bonds, according to the way the long sides (stretchers) or short sides (headers) are placed.

Brick was the chief building material of ancient Mesopotamia and Palestine, which had little wood or stone. The inhabitants of Jericho in Palestine were building in brick about 9000 years ago. Sumerian and Babylonian builders constructed ziggurats, palaces, and city walls of sun-dried brick and covered them with more durable kiln-baked often brilliantly glazed brick, arranged in decorative pictorial friezes. Later the Persians and the Chinese built in brick, for example, the

Great Wall of China. The Romans built such large structures as baths, amphitheatres, and aqueducts in brick, which they often covered with marble facing.

Size of bricks

To allow of the bricks being properly bonded, the width should be about one-fourth inch less than half the length, so that one brick laid lengthwise along the wall will just cover two bricks laid crosswise with a joint of mortar between them.

Size of bricks differs in India from state to state. However, the standard size of brick in Uttar Pradesh is 9″×4⅜″×2⅞″ (23 cm×11 cm×7 cm).

During the last decade the prices of bricks raised exorbitantly. Thus to make more profit the brick kiln owners reduced the overall sizes of the bricks. The thickness of brick has been reduced drastically to 2 inches. Therefore it is necessary to check the dimensions of bricks before placing the order. Also check the dimensions of bricks before accepting consignment.

Standard brick dimensions

No of bricks	½	1	1½	2	2½	3	3½	4
Dimensions	4⅜″	9″	1′-1⅝″	1′-6½″	1′-10⅞″	2′-3½″	2′-8⅛″	3′-¾″

Measurement of bricks

a). Eight stretchers laid square end and splay end in contact in the straight line, to measure 72 inches.

b). Eight headers laid side-to-side, frog upwards, in a straight line, to measure 35 inches.

c). Eight bricks, the first frog downwards, and then alternately frog-to-frog and back-to-back, to measure 21½ inches

The size of well-burnt old size brick may be 9 inches × 4⅜″ ×3″ (230×110×75 mm).

Modular brick

As per Indian standards institution, metric dimensions of bricks are 8″×4″×4″ nominal (19 cm × 9 cm × 9 cm).

Characteristics of good Brick

Bricks should fulfil the following conditions: —

1. Bricks should be non-absorbent unless to be protected by a non-absorbent facing, such as cement rendering.
2. Bricks should be well baked throughout.
3. Bricks should be uniform in size, shape, and texture.
4. Bricks should have sharp arises or edges.
5. Bricks should be free from flaws, stones, and lumps of lime.
6. Bricks should ring well when two are struck together.
7. Bricks should be strong and require repeated blows before breaking.
8. Bricks should stand handling and cartage well without injury.

9. A good ordinary old size brick should not weigh less than 2.25 kilograms.
10. The specific gravity is about 1.8 (One cubic metre weighing about 1800 Kilograms).
11. The length of brick should be double the width plus the thickness of one vertical joint.
12. 1000-number old-size bricks closely stacked occupy about 1.5595 cubic metres (55 cubic feet).
13. Bricks should not absorb water more than ⅕ (20%) of their weight, if kept immersed in water for a period of 24 hours.
14. Bricks should be free from cracks, flaws, or lumps of any kind especially lump of lime.

Brick masonry

Brickwork masonry is produced when a bricklayer uses bricks and mortar to build up structures such as walls, bridges, and chimney. (Brickwork is also used to finish openings such as doors or windows in buildings made of other materials.) Where the bricks are to remain fully visible, as opposed to being covered up by plaster or stucco, this is known as face-work.

Bricks are laid to expose their ends (Header bricks), or sides (Stretcher bricks). As the work progress, the bricks are laid in rows called courses. The manner in which the bricks overlap as they are laid up is called the bond. Types of bond include English bond, Flemish bond, and Herringbone bond, but the most common type of brickwork seen these days is the simple stretcher bond, showing only the long side-surface of the brick.

Because only the outside of finished brickwork is visible, cheaper grades of brick are commonly used for the hidden parts of a wall. In an old red-brick house, behind the front of red, the rest of the walls are often made of softer yellow bricks. The colour situation may be reversed if the house was built when red bricks were out of fashion. So with certain types of bond (e.g. garden wall bond) it is possible to use a higher ratio of cheaper bricks to more expensive bricks, making for a cheaper wall of the same dimensions. On the same house, sometimes a more economical "garden wall" bond has been used at the side and rear compared to the front.

The thickness of brickwork is measured in units of brick. If bricks are put down end-to-end with the long side facing you (stretchers) and then another row on top, the wall thickness is half a brick.

There are rules of bonding, which have some exceptions. These specify the overlap between courses that is visible outside the wall, and also the overlap which must be made within the wall, for walls which are more than half a brick thick.

Brickwork, like un-reinforced concrete, has little tensile strength, and works by everything being kept in compression.

Brickwork arches can span great distances, and carry considerable loads.

Bricklayers use a variety of specialist tools to carry out precise and accurate results from architect's plans. A fully qualified bricklayer will be able to progress into technical, supervisory and management roles with training.

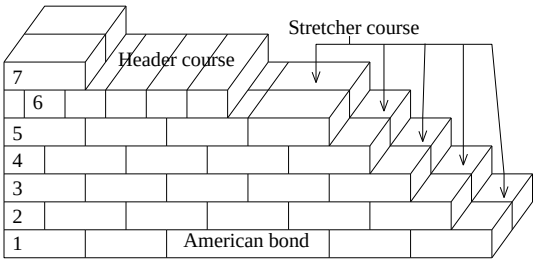
Types of bonds in brickwork

When laying bricks, the manner in which the bricks overlap is called the **bond**. A brick laid with the longest side exposed is called a stretcher brick, as opposed to a header, where only the smallest end of the brick is exposed to the weather. The length of one stretcher is the same as two header bricks, side-by-side, including the 10 mm joint between.

The thickness of a brick wall is measured using a unit of length known as 'the brick'. This standard can be used consistently with the wide variety of brick sizes available ("modular, "normal" brick, etc.). The length of the longest face for a particular size of brick equals "one brick", for the purposes of measuring a wall built from such bricks.

There are number of recognized bonds to which certain rules of construction apply. In repair work, the existing bond should be followed wherever possible.

American bond



American common bond is made by laying the courses of headers where they are separated by approximately five to seven courses of stretchers. On occasion American common bond can be found with nine courses of stretchers between courses of headers. The stretcher courses are most often an uneven number. English common bond is an early variation with only three courses of stretchers between header courses.

It is quickly laid and is strong as other bonds. Every fifth or sixth course consists of header, while the other courses consist of stretcher.

Basket bond

This decorative pattern imitates the weave of a basket. It's also sometimes called a basket weave bond, and there are many variations on the weave pattern, some very elaborate.

Chinese bond

As in Flemish bond, but all the bricks are laid on edge. Unusual, but used to make a light weight structure or economise on bricks and creates a semi-cavity wall.

Dutch bond

This bond is also known as English Cross Bond, in which the courses are alternatively made up of headers and stretchers.

English bond

A row of bricks is called a course. If the bricks are laid in alternate courses of header and stretchers, as shown herein after’ the wall is in English Bond

The joints showing on the face of a wall are called perpends. In English bond, perpends are staggered by 2¼ inch, so that there is a header above and below the middle of each stretcher.

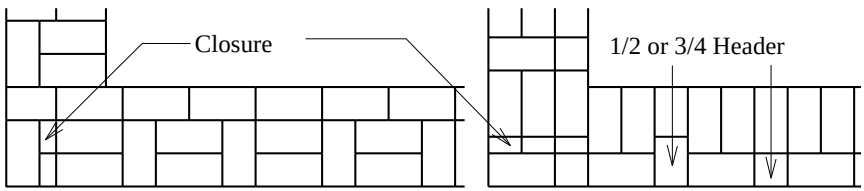
The bricks on the corner of a wall are called quoin bricks. In corner of an English Bond, a quoin header becomes a stretcher on turning the corner, and vice-versa.

This bond is made up of alternating courses of stretchers and headers. This produces a solid wall that is a full brick in depth. English bond is fairly easy to provide and is the strongest bond for a one-brick-thick wall. If only one face of an English bond wall is exposed, one quarter of the bricks are not visible, and hence may be of low visual quality.

The bond is formed by a part (or bat) brick known as a 'queen closer'. This is a brick cut in half lengthways, generally along the frog and laid in the course next to the corner brick or “quoin header”. Whereas the stretcher or half bond is formed by successive courses being staggered by half a brick, the Flemish and English bonds are now staggered by a quarter, resulting in a stronger bond (the constructional self-weight being distributed over a greater area). This bond, as well as Flemish bond, does not necessarily have to be one brick thick, they can be built using 'snap headers' i.e. headers cut to half their length, which give a full brick appearance. They are often used in cavity walls when matching existing solid wall patterns.

This bond is also called English cross bond or Dutch bond.

Flemish bond

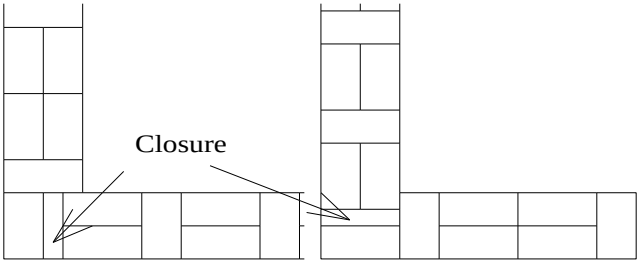


Flemish bond Single

Consists of alternate headers and stretchers in every course, each header centering on the stretchers in the courses above and below.

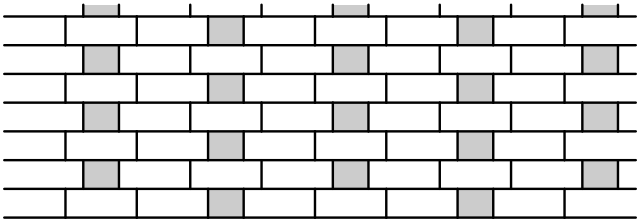
It is also known as Dutch bond, has historically always been considered the most decorative bond, and for this reason was used extensively for dwellings until the adoption of the cavity wall. It is created by alternately laying headers and stretchers in a single course. The next course is laid so that a header lies in the middle of the stretcher in the course below. Again, this bond is one brick thick. It is quite difficult to lay Flemish bond properly, since for best effect, all perpends (vertical mortar joints) need to be vertically aligned. If only one face of a Flemish bond wall is exposed, one third of the brick is not visible, and hence may be of low visual quality. This is a better ratio than for English bond, Flemish bond's main rival for load-bearing walls.

Flemish bond, double



When both inner and outer surfaces of an exposed wall are laid in Flemish Bond, all headers being true or full headers, the bond is termed as "Double Flemish Bond"

Garden bond (Flemish garden bond)



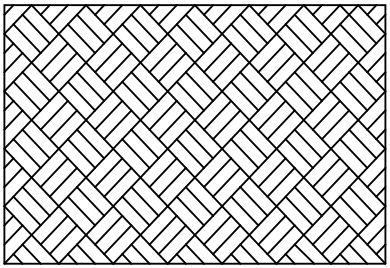
This bond consists of three stretchers in each course followed by a header. This bond may have from two to five stretchers between headers.

Header bond

Header bond (also known as **Spanish bond**) was a very common bond for bearing walls. It is composed of header bricks, set in rows that are offset by an entire brick, which produces a solid easy-to-lay bond. It is the most used bond in historical Spanish brick constructions.

A brick laid with an end showing on the face is called a header. If all the bricks are laid as headers, the brick in course overlapping by 2¼ inch (half of the header face), the bricks are said to be laid in header bond. This gives a strong transverse bond but longitudinally it is inferior to stretcher bond and the header arrangement does not look as pleasing as the stretcher arrangement. In practice, the header bond is almost confined to two uses: for walls curved on plan, in which the header enables the curve to be followed closely; and in foundation footings.

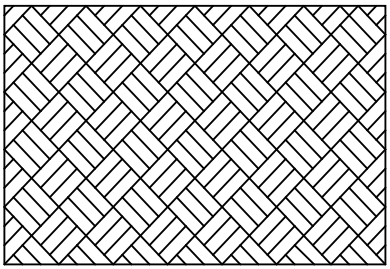
Herringbone bond



A zigzag arrangement of laying bricks or tile, in which the end of one brick is laid at right angles against the side of a second brick

When bricks are laid on alternating angles, it is called a Herringbone. This is primarily a decorative style, more often used for paving or fireplace reflectors than for walls. This style is also sometimes called by its Latin name: Opus spectrum.

Herringbone 90 degree

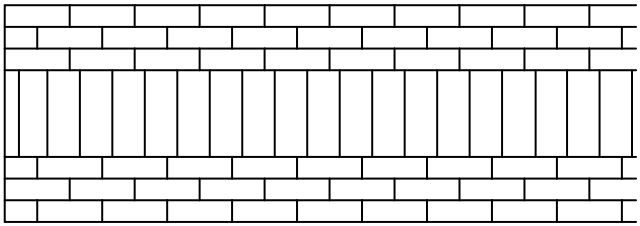


Rat-trap bond

These bonds are variations on normal bonds. They use a high proportion of stretchers, and hence require fewer facing bricks than normal bonds. This makes them less sturdy, but cheaper. As such they are most commonly used for garden- and other non-load-bearing walls.

Rattrap bond is a type of garden wall bond in which the stretchers and headers are laid on their sides, with the base of the stretcher facing outwards. This gives a wall with an internal cavity bridged by the headers, hence the name. The main advantage of this bond is economy in use of bricks, giving a wall of one brick thickness with fewer bricks than a solid bond. Rattrap bond was in common usage in England for building houses of fewer than 3 stories up to the turn of the 20th century and is today still used in India as an economical bond, as well for the insulation properties offered by the air cavity. Also, many brick walls surrounding kitchen gardens were designed with cavities so hot air could circulate in the winter, warming fruit trees or other produce spread against the walls, causing them to bloom earlier and forcing early fruit production.

Soldier course



Soldier course a course in which the bricks stand on end.

Stretcher bond

A brick laid with the long side showing on the wall face is called a stretcher. Stretcher bond consists of stretchers laid to overlap by a half brick length. This bond is used in walls half a brick. It should not be used in thicker walls, as it does not provide a transverse bond.

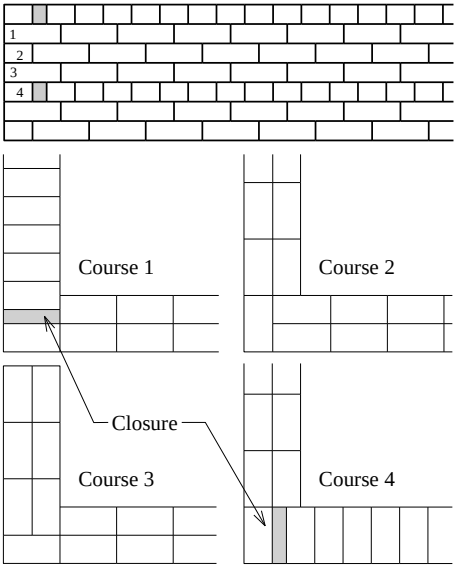
Stretcher bond (also known as running bond or monotonous stretcher bond) is the most common bond in modern times, as it is easy to lay, with little waste; entirely comprised of stretcher bricks, set in rows (or "courses") that are offset by half a brick.

Running bond uses no header bricks, allowing for a thin wall of one layer (half of a "brick" unit). Two such walls may be built close together with a gap between. The two "skins" are usually tied together at regular intervals using wall ties. For this reason this bond is sometimes known as "cavity wall bond", although it is possible to give the appearance of other bonds in a half-brick cavity wall, either through extensive brick-cutting or the use of purpose-made half-bricks. In some climates the cavity may be filled with cavity wall insulation.

Stretcher bond may also be used to build a single Wythe (one brick thick) wall without a deliberate cavity. In this case, wall ties are used to hold the two Wythes together. The main advantage of this technique is that it allows walls with both faces visible, such as domestic dwarf walls, to be built using low-cost bricks that have only two fair faces, called "face bricks". Laying any such brick as a header would reveal a poorly finished header face on one side of the wall. These walls are also used in situations where stronger load bearing capacity is required than that given by a single stretcher bond wall with engaged piers.

Three & one bond

In this bond, there are three courses of stretchers to one course of headers. The stretcher courses are staggered 4.5 inches in relation to each other, but the stretchers are staggered 2.25 inches in relation to the header course. This bond is also known as English garden-wall bond.



Use of closure

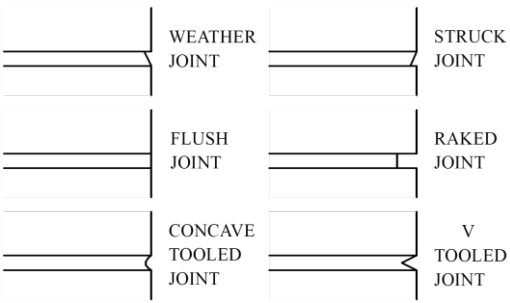
At a corner and at a stopped end a brick smaller than the standard size, called a closure, must be used. A Closure is 2¼ inch wide (half the width of a header).

The purpose of the closure is to bring the end or corner to a flush face.

There are three kinds of Closure: Queen closure, Bevelled closure, and King closure. On the wall face, they look the same.

An important rule of bonding is that the closure is placed next to the quoin header. Bonding in any particular bond varies with the thickness of the wall.

Joints in brickwork



The bottom surface of a brick is called the **BED**.

The horizontal mortar joints are called **BED JOINTS**.

The vertical joints on the face are called **PERPENDS**.

A good bricklayer takes care to keep perpends on a true vertical line. When the face joints are finished as the work proceeds i.e. drawing the trowel or other tool along the face of the joint to give a smooth durable finish, this work is called **JOINTED**. The mortar of the joint face is the same as that in the beds and other joints.

If the joints are raked out to a depth of at least 15 mm and then filled with a specially prepared mortar and smoothed with the trowel or other tool, this work is called **POINTED**

There are various types of jointing and pointing finishes. Weathered Pointing is supposed to be most durable, as the rain runs off the edge. Stuck Pointing should never be used in outside work, as the water rests on the edge. The **HOLLOW KEYED** joint looks well, as the recess throws a shadow.

TUCK-POINTING is suitable for renovating old brickwork where the bricks have crumbled at the edges. It consists of a stopping of lime or cement lime and sand mortar coloured to the tint of the bricks. While cement jointing, mortar is then pressed into the stopping with jointer's tool; the top and bottom edges being cut off with a Frenchman worked along a bevelled straightedge or rule.

Strength of brickwork

Strength of brickwork usually depends on that of the mortar and not so much on the strength of bricks itself. A safe load of 2 to 4 tons per square foot (2.187 to 4.375 kg per square cm) may be allowed on brickwork built of common, well-burnt bricks and lime mortar (1 lime, 2 sand). Cemented brickwork made of well-burnt bricks built in cement mortar (1 Portland cement and 5 sand) can safely sustain a pressure of 8 to 10 tons per square foot (8.75 to 10.94 kg per Sq cm).

The cleaner and sharper the sand, the greater is the strength. Care should be taken in brickwork that the bond is good through out, no joint between the brick coming in line either lengthwise or across the work.

Workmanship Brickwork

Testing of bricks at work site

For use in any important construction work, test the bricks for:

a) External appearance (Colour)
b) Size and shape
c) Structure
d) Hardness
e) Soundness
f) Compactness and homogeneity
g) Freedom from efflorescence

Check that: —

1. The colour of bricks is uniform (brick red or yellowish).
2. Bricks are free from cracks, flaws, or lumps of any kind especially lump of lime

3. Examine the fractured surface; this should be free from holes and grits.
4. A broken surface should show a homogeneous, compact structure; a porous structure or one showing grits or lumps of stone are objectionable.
5. The sides of bricks are uniform with straight surfaces and sharp arrises.
6. The length of the brick should be double the width plus the thickness of one vertical joint.
7. Judge the Hardness by inability to scratch with the thumbnail.
8. Two sound bricks, when struck-together, gives a sharp metallic ring, and would not easily break.
9. The strength of a brick can roughly be judged from the force required to break the brick with hammer.
10. Brick should not break if allowed to fall on its end on firm ground from a height of 2.1 metres (7 feet).
11. Test compactness and homogeneity of structure. Low (less than 5%) absorption of water also proves a compact structure.
12. No brick after 24 hours immersion in water shall absorb, water more than 20% of its weight, i.e. bricks should not absorb water more than one fifth of their weight.
13. A brick, soaked in water for 24 hours, if dried in the shade, should not show off efflorescence (deposits of white salts).

Workmanship

1. Care should be taken in brickwork that the bond is good throughout, no joints between the bricks coming in line either lengthwise or across the work.
2. In cross walls abutting against a main wall at right angle the bond is obtained by placing a closure 4½ inches from the face in every alternate course of the main wall. This arrangement leaves in every course of the main wall a space of 2¼ inches deep into which a corresponding projection of cross wall fits in.
3. The heading course of the cross wall enters the stretching course of main wall.
4. Special attention should be taken in the construction of stopped ends of walls, as these are often required to take concentrated load from lintels, etc.
5. Alternate courses are un-bonded.
6. When using old size bricks, the course at the top of the plinth (below damp proof course) and sills, at the top of the wall just below the roof slab and the top of the parapet, shall be laid with 'Brick on edge' (A course of brick laid on edge is called 'Row lock' course).
7. Corners shall be built by using 'Punja Bricks' (Five bricks, not 3 bricks).
8. Brickwork should measure four courses of bricks and four joints to a foot [305-mm].
9. Typical shape and arrangement of these bricks are shown in the sketch hereinafter.
10. ¾ and ½ bats must be used to complete the proper bond.
11. For further details refer 'IS—2212', Clause 10.1.
12. Firebricks should be of new clay of the finest quality, cleanly moulded, true, and free from all flaws, or cracks.

Construction of walls 1-brick thick & over

1. Bricks to be soaked in water until bubbles cease to come up. Adequately soaked bricks should only be used. A properly soaked brick if broken in to two halves should show soaking effect at every particle of the brick.
2. No broken bricks to be used except as closures
3. Before commencement of brickwork, get the centre lines of all walls marked on the top of foundation concrete as well as on the vertical faces of the excavated trench by applying at least 4 inches wide plaster extending 2 inch on either side of centre line.
4. Do not use inferior quality bricks in the foundation.
5. Brickwork in foundation does not require application of any plaster or finish. The joints in the brickwork shall be finished flush in the same mortar as the work proceeds.
6. Brickwork should be built in English Bond. Do not allow mason to use ¾ brick to construct the right-angled junction of wall. This is a wrong practice, every ¼ brick goes as waste, and the joint is improper. Insist that mason uses Queen Closure for proper English Bond.
7. Courses truly horizontal and the work strictly plumb.
8. Joints to be broken vertically and thickness of joint should not exceed 10 mm.
9. Ensure that your mason properly constructs T-junction of walls.
10. Modular bricks, of size 8″×4″×4″, are not commonly used. Bricks of size 9″×4½″×3″ are old size bricks. When using old size bricks, top course of all plinths, parapets, steps, and top of wall below roof or floor slab should be laid with brick on edge. Use 'Punja' bricks (5 bricks) at right-angled corner instead of using only three bricks.
11. Bricks are generally laid frog up position (Frog is the hollow portion of a brick where manufacturer gives their trade name at the time of manufacture of bricks). While laying brick course the brick can also be laid in frog down position. In this case, see that the frog is filled with mortar before the brick is laid. The frog affords a key for the mortar, which holds the brick on top firmly in place.
12. Height of brick courses at every part of a building should remain the same. For old size bricks, four course and four joints should remain nearer or equal to 12 inches (30.5 cm) i.e. Brickwork should measure four courses of bricks and four joints to a foot [30.5 cm].
13. To maintain this ask mason to prepare a "Storey Rod" at least of height from proposed finished floor level (top of Damp Proof Course) to the soffit of the door/window lintel. Check the height of brickwork at different point of the building after every fourth course is laid. This will enable you to maintain the lintel height of entire building at same level.
14. The work shall not be raised more than eight courses per day.
15. Ensure that the brick joints are raked out squarely, as the work proceeds, to a depth of 12 mm for plaster and 15 mm for pointing.
16. All masons are careless about making sides of doors and windows openings truly vertical. Check these frequently as works goes up.

17. Tables shall be formed at every ninth course and kept full of water. All brick work to be watered three times a day for 10 days and afterwards twice a day for a month.

Construction of walls ½-brick thick

1. All half-brick (4½″) thick wall shall be built in stretcher bond with cement mortar of ratio (1:4). Half-brick thick walls should be built off the sub floor.
2. For half-brick walls exceeding 5 feet in height provide two numbers 6 mm diameter round bars at every fourth course with ends of bars properly anchored in main walls. The lap in bars where required shall not be less than one feet. Keep not less than 25 mm mortar cover to these bars in the direction of the joints
3. For half brick wall up to or exceeding door height provide a Reinforced Cement Concrete lintel band not less than 100 mm thick reinforced with 4 numbers 8 mm diameter tor bar (twisted or deformed bars) and 6 mm diameter round bar stirrups at 20 cm spacing.
4. For half brick walls exceeding 10-feet in length and exceeding 8 feet in height, provide a vertical Reinforce Cement Concrete band of size 4½″×4½″ (115×115mm) reinforced with 4 numbers 8 mm diameter tor and 6 mm diameter round bar stirrups at 6″ (150 mm) spacing.

Requirement of cement

Description of item	**Ratio**	**Unit**	**Old size bricks**	**Modular bricks**
Brick work in well-burnt bricks straight on plan or to a curve, exceeding 6 mitres mean radius, built in cement and sand mortar.		Cu m	Cement* in kg	
	1:3		123.00	113.38
	1:4		95.84	87.96
	1:6		64.06	58.47
	1:8		47.93	44.32
Brick work in well-burnt bricks straight on plan or to a curve, exceeding 6 mitres mean radius, built in gauged mortar	1:1:6		60.48	56.82
	1:1:8		47.93	43.62
	1:2:9		40.49	37.72
Old size bricks – 9″×4½″×3″, Modular bricks – 8″×4″×4″				
One cubic meter = 35.31 cubic feet. * quantity of cement is inclusive of 2½ % wastage				

Estimating –brickwork

Lightening calculations of materials

Material required for 10 square metres (107.64 sq feet) of brick wall

Mix	115 millimetre thick (½-bk wall)			230 millimetre thick (1-bk wall)		
	Cement	Brick	Sand	Cement	Brick	Sand
Ratio	bags	Nos.	cum (cu ft)	bags	Nos.	cum (cu ft)
1:3	2.75	530	0.30 (10.60 cu ft)	5.70	1100	0.60 (21.18 cu ft)
1:4	2.10	530	0.30 (10.60 cu ft)	4.40	1100	0.62 (21.90 cu ft)
1:6	1.40	530	0.30 (10.60 cu ft)	2.95	1100	0.62 (21.90 cu ft)
1:8	1.06	530	0.30 (10.60 cu ft)	2.20	1100	0.62 (21.90 cu ft)

And

Mix	345 millimetre thick (1½-bk wall)			460 millimetre thick (2-bk wall)		
	Cement	Brick	Sand	Cement	Brick	Sand
Ratio	bags	Nos.	cum (cu ft)	bags	Nos.	cum (cu ft)
1:3	8.50	1600	0.90 (31.78 cu ft)	11.20	2150	1.20 (42.38 cu ft)
1:4	6.50	1600	0.91 (32.13 cu ft)	8.70	2150	1.22 (43.08 cu ft)
1:6	4.40	1600	0.92 (32.50 cu ft)	5.80	2150	1.22 (43.08 cu ft)
1:8	3.30	1600	0.92 (32.50 cu ft)	4.35	2150	1.22 (43.08 cu ft)

Calculations of number of bricks

Thickness of wall	Constant
½ Brick	0.0053
1 Brick	0.0106
1½ Brick	0.016
2 Brick	0.0213
2½ Brick	0.0267
3 Brick	0.032

If S = superficial area of wall in sq ft, then

S × Constant × 1000 = Number of bricks

Thumb rules

1 Cum brick work (6 mm joints) contains bricks (old size) = 510 Numbers
1 Cum brick work (10 mm joints) contains bricks (old size) = 465 Numbers
1 Sq m flat brick floor contains bricks (old size) = 38 Numbers
1 Sq m brick on edge floor contains bricks (old size) = 58 Numbers
1 Sq m brickwork 115 mm thick contains brick (old size) = 58 Numbers
1 sq m honey comb brickwork 115 mm thick contains bricks = 35 Numbers
For 1 cum brick ballast numbers of bricks required (old size) = 370 Numbers
For 1 cum brick ballast, brick bats required = 1.15 cum
For 1 cum brickbats, bricks required (old size) = 325 Numbers

Bricks required per sq m plinth area = 538 Numbers

1000 Bricks of normal size closely stacked, occupy about = 1.557 cum

Quantities of mortars

Dry mortar for 1 cum (35.31 cu ft) brick work	= 0.30 cum (10.6 cu ft)
Dry mortar for 10 sq m (108 sq ft), pointing	= 0.061 cum (2.15 cu ft)
Dry mortar for 10 sq m, plastering 12 mm thick	= 0.183 cum (6.50 cu ft)
Dry mortar for 10 sq m, 115 mm (½ brick) thick wall	= 0.338 cum (12 cu ft)
Cement required per sq m of plinth area	= 1.3 Bags (65 kg)
0.283 cum (10 cu ft) loose Portland cement plus 10.23 litres of water will give	= 0.236 cum (8.35 cu ft) of neat cement slurry
1.33 cum dry mortar when wetted gives about	= 1 cum wet mortar

Qty for Metric size bricks (modular bricks)

The following constants may be assumed where walling is measured as 20 cm thick for 1 brick thick wall and 10 cm thick for half brick walls, using 19×9×9 cm size bricks:

Analysis

As brick's sizes differ widely, the method of finding brick and mortar requirement is explained below:

Size of brick = 19×9×9 cm (New size bricks),

Size of joint = 1 centimetre (⅜ inch)

One-brick thick wall

A portion of wall 1 meter long, 1 meter high, and 19 cm wide will have: -

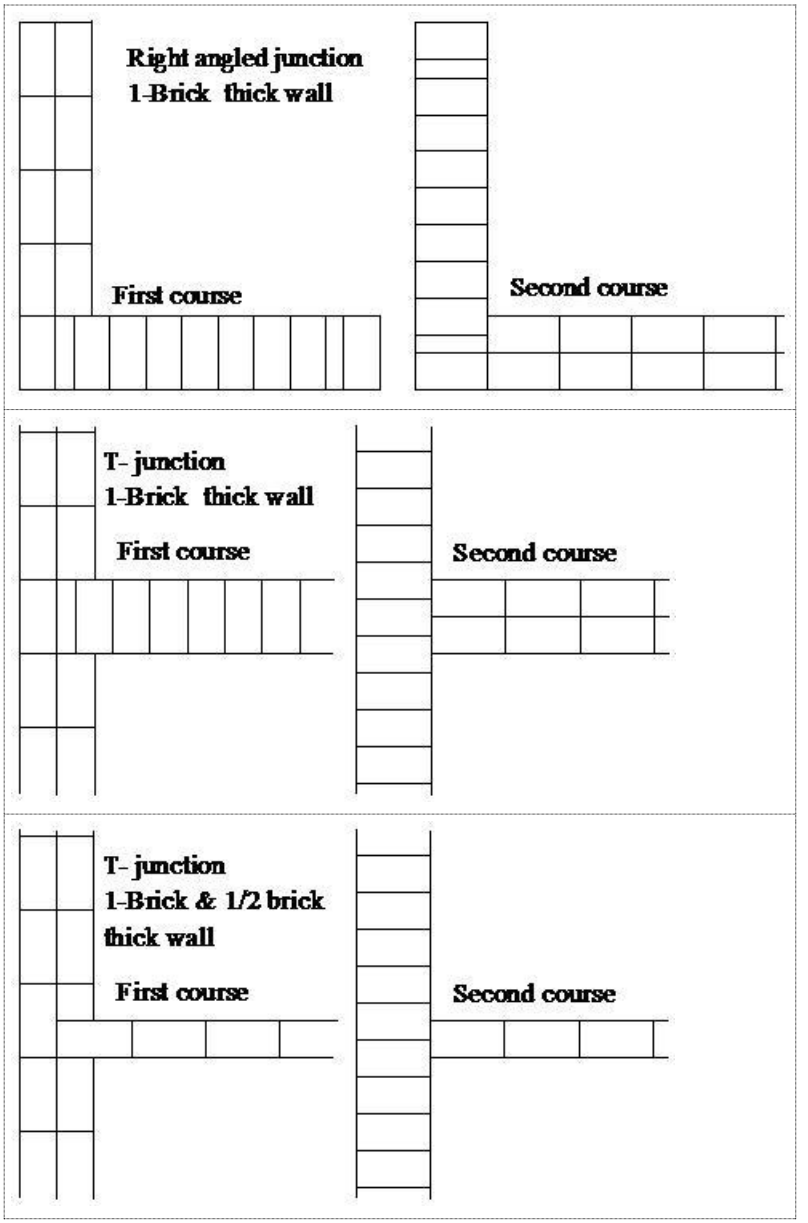
Volume of brickwork	= 0.19 cum
Number of bricks	= 10 courses×10 bricks each course =100 bricks
Volume occupied by bricks	= 100×0.19×0.09×0.09 = 0.1539 cubic metre
Volume occupied by joints	= 0.0361 cum [i.e. 0.19 – 0.1539]
Add 5% for frogs	= 0.0018 cum
Total mortar for joints	= 0.0379 cum
Bricks per cum	= 527 or 532 numbers [after adding 1% for wastage]
Mortar per cum	= 0.20 or 0.21 cum [after adding 5% for wastage]

Half-brick thick wall

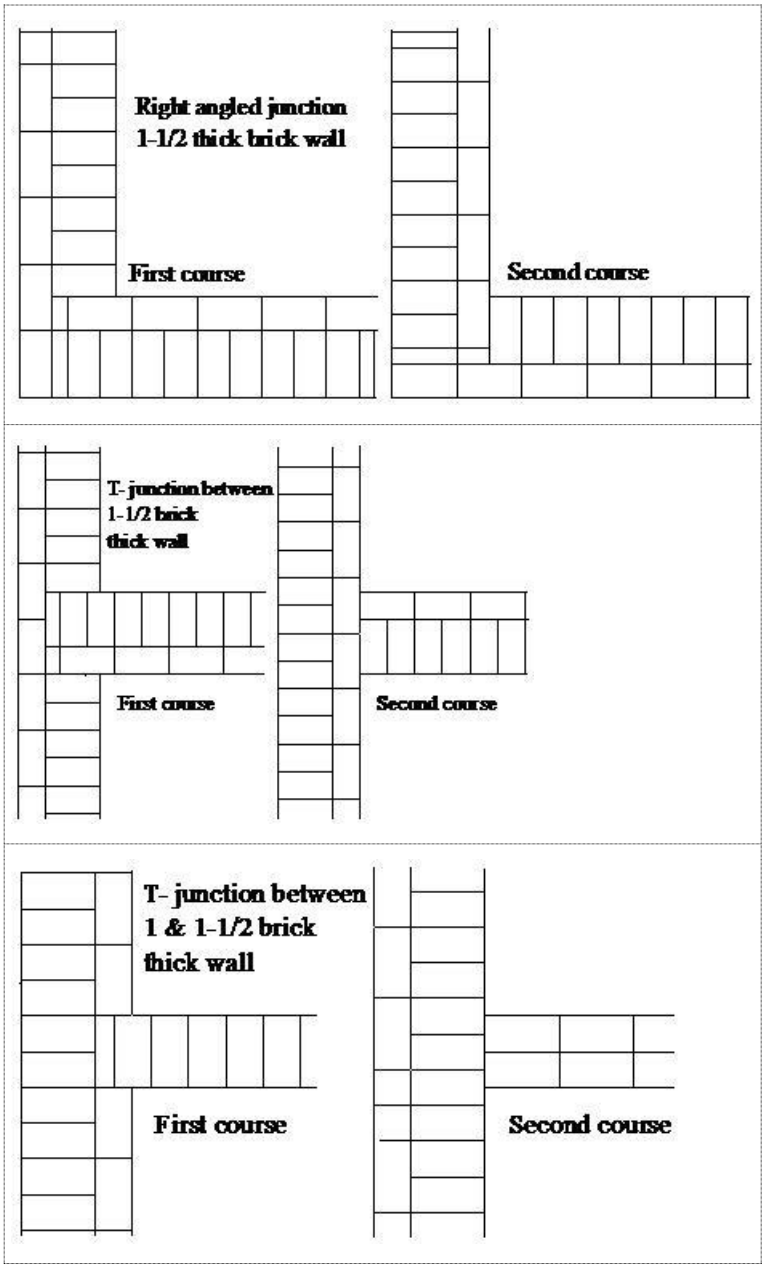
Bricks per cum = 561 numbers. [After adding 1% for wastage]

Mortar per cum = 0.16 cum. [After adding 5% for wastage]

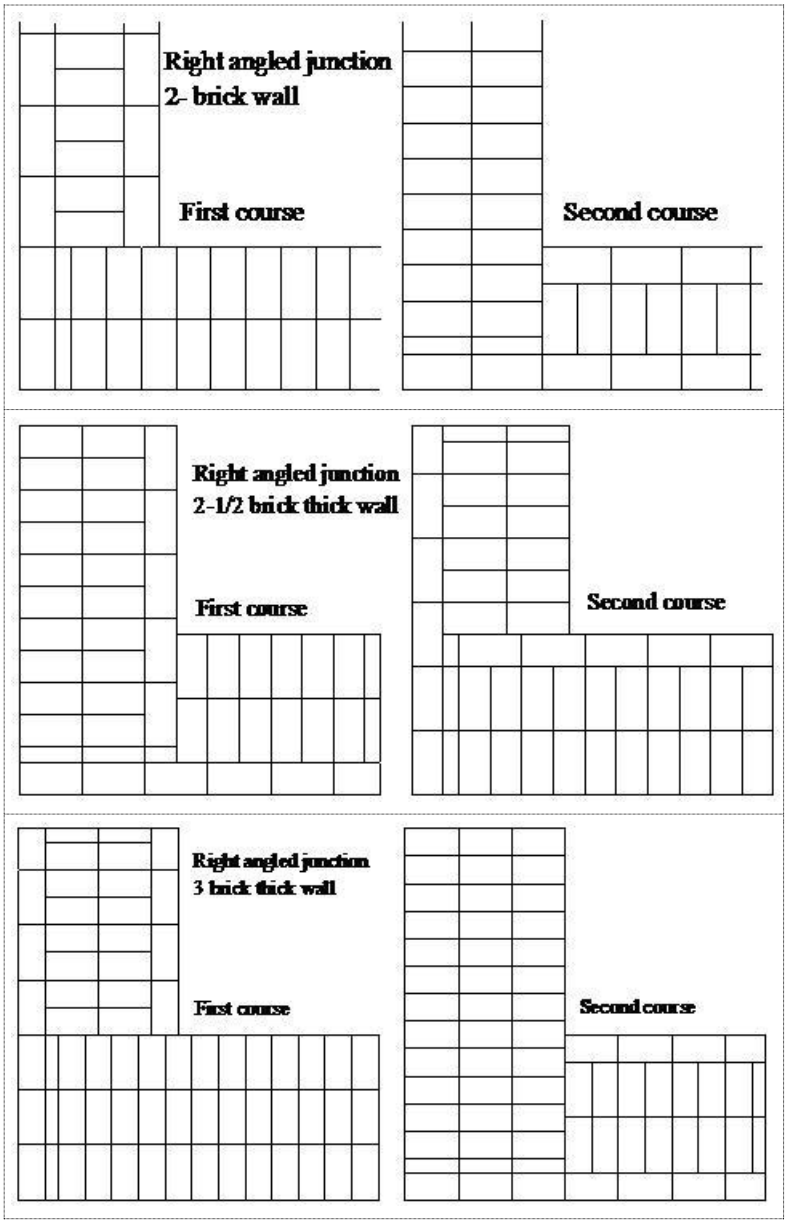
Details of 1-brick thick walls



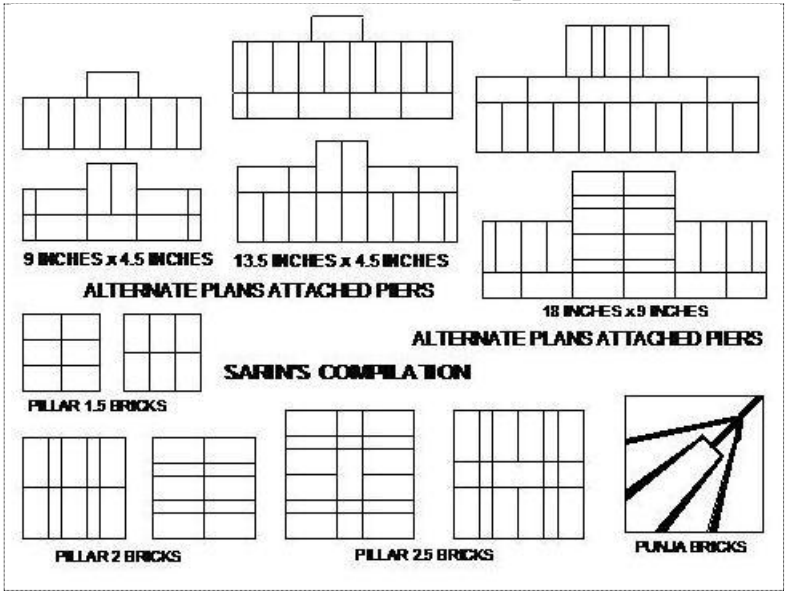
Details of 1½ -Brick thick walls



Details of 2 & 3 -Brick thick walls



Details of 2 -brick walls & attached piers



Parapet Walls

Whenever tops of walls are exposed, penetration by rain from above is much more likely than through vertical surfaces. All such walls should have an impervious capping. It is also a wise step to provide a damp proof course below the capping.

Water penetrating copings may dissolve chemicals present in bricks or mortar and by transferring these to the point at which the water leaves the wall by evaporation cause at least disfiguring efflorescence or at worst expansion and disruption of the jointing and eventual destruction of the wall itself.

Fire resisting materials

Brickwork in lime or cement mortar, granite and other building stones, iron, steel and copper, teak and other hard timber not less than 50 mm (2 inches) thick, tiles, brick and terra-cotta coverings and corbels, flagstones when used over arches, but not when exposed on underside or supported at ends only; concrete filling between joists.

Columns & piers

A pier is a member of whom width does not exceed four times its thickness. Code of practice limits the 'Pier' to such a member bonded to a load-bearing wall. It defines a similar but isolated member as a 'Column'.

Brick piers under pressure invariably fail by longitudinal splitting and spreading apart, thus showing that the tensile strength of bricks and mortar is an important factor.

Water penetration

Through brick walls

Most bricks are, to some degree, absorbents. Solid walls generally resist penetration in depth. Rain, which beats on to the external surface of walls is partially absorbed by bricks, and slowly penetrates into the wall. The depth of penetration being proportional in part to the duration of the rain and in part to the volume of voids in the bricks which may help to reduce penetration by virtue of their capacity to hold water. Walls give up their moisture content by evaporation when rain stops. Thus in periods of continuous rains, even solid walls of considerable, thickness may allow water to penetrate them.

Even when bricks are impervious, joints are vulnerable and these are in any case subject to cracking due to movement or shrinkage and so liable to destroy the wall's efficiency as excluder. Thus in many cases walls amply thick enough to support the structure and its loads are not capable of safely excluding rain. In domestic buildings 230 mm thick walls have been extensively used, often with the addition of a protective coat of cement rendering externally. This can be and often has proved effective in excluding water but the real reason for its use has often been to cover the low cost bricks used in the construction.

Walls of very porous bricks i.e. bricks that have a high proportion of voids in their structure, often prove efficient water excluder, simply because of their capacity to hold large quantities of water.

Rendering for best results should be porous so that water penetrating its surface can later emerge through the external surface. If rendered surfaces crack and this is always likely because of the shrinkage which occurs in cement when it sets), water readily enters the cracks to become trapped behind its surface thus increasing the likely hood of penetration through the wall or of the loosening and eventual dislodgement of the rendering particularly if trapped water becomes frozen.

It is advisable to include lime in the mix of the rendering to impart "flexibility" (1:1:6 and 1:2:9 are widely used mixes) and to finish the rendering with a rough or textured finish.

Efflorescence

Efflorescence is more common in bricks that are under burnt and soft, and occurs frequently on brickwork in the lower portion of walls, where ground moisture rises by capillary action. Efflorescence can be prevented by —

1. Avoiding brick-earth containing salts which causes efflorescence,
2. Over-burning rather than under-burning of bricks,
3. Avoiding any salty water in preparing either brick-earth or mortar,
4. Cutting off soil-moisture by using effective damp-proof course

Treatment of efflorescence

Efflorescence is the name given to the white deposit often seen on the face of the wall. This deposit consists of chemical salts such as sulphates of calcium, sodium, potassium, and

magnesium. These are soluble in water, and when water dries out from the wall, the salts are drawn to the surface of brick and to the surface skin where they crystallize. When crystallization takes place, it is accompanied by expansion, which may disrupt the brickwork and/or mortar. This is a frequent cause of surface decay in walls. The salts may be contained in the bricks, as they are sometimes present in the clay from which the bricks are manufactured, or they may be in the mortar as they are frequently present in Portland cement.

If the bricks are soaked for the required time in water that is frequently changed, the soluble salts in the bricks will be leached out, and subsequent efflorescence will be reduced.

Efflorescence may occurs on brick facing which is invariably after saturated walls have been subjected to warm sunshine, bringing the dissolved salts in the bricks or mortar to the surface in crystals, simplest and the best treatment is to brush of the dry crystals at regular intervals.

Unfortunately, there is no rapid or certain cure for efflorescence. It will be understood that, as water alternatively soaks into and evaporate from the wall, it draws more and more of the salts from the wall material. When there is a good deposit of the salt on the wall-face, it may be brushed or washed off. There is no effective chemical treatment. However, washing and brushing get rid of some of the salts.

A coat of common water bound distemper (non-washable) or omission of any coating to the new plaster to the end of at least 6 months from occupation is a wise precaution. This allows moisture, which is in the work to dry out gradually. Brushing is advised for external work (but without alternate washing), which disclose whether the trouble is diminishing, if it fails to do so the source of continued presence of moisture should be sought.